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FUTURE TRENDS OF ELECTRIC POWER IN THE ASIAN AND PACIFIC REGION*

(Item 7 of the provisional agenda)

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* This paper was prepared by Mr. Nigel John Dallas Lucas at the request of the ESCAP secretariat. The views expressed in it are those of the author and do not necessarily reflect those of the United Nations.

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SUMMARY

Trends

Growth in demand for electricity in the region over the last twenty years has been strong, especially high growth was experienced in the nineteen sixties. A reduction of the rate of growth in demand in the seventies appears to have resulted largely from the slackening of output. The relationship between GDP per capita and electricity use per capita was rather stable across countries and in time; the trajectories for the countries of the region were not much disturbed in the seventies.

In the nineteen eighties there begins to appear evidence of some decoupling of electricity demand and national income. The new trend is not sufficiently well established to allow one to be confident of its extent or duration. It may well be that forecasts of future electricity demand in the region do not make adequate allowance for the extent of this structural adjustment to higher prices.

Structural adjustment

The nature of the power systems in the region is such that the transition from oil as a fuel depends largely on new investment. As a consequence the transition from oil has been delayed and is detectable in many countries only recently. The heavy investments which have been made to mobilise alternative fuels for power generation will have a pronounced effect in the next few years. The percentage of electricity generated from oil products, excluding China and India, will drop from about 60 per cent in 1980 to 20 per cent in 1990. The exact figure is hard to predict because oil will be the marginal fuel and will absorb the discrepancies between forecast demand and outturn.

Progress has been less dramatic in other aspects of the structural adjustment to high oil prices. Losses on some power systems in the region remain high; there has been some improvement but in most cases systematic programmes of loss reduction have not been implemented.

Tariffs are a means by which utilities adjust their relationships with consumers. International Banks have increasingly introduced into loans covenants specifying financial targets. These covenants are the motivation for tariff increases in many countries. There appears to be declining interest in long run marginal cost based tariff policies and considerable scepticism about their relevance in the region.

/Future

Future sources of power

The details of the future mix of generating plant are reasonably clear up to 1995/2000. The substitution for oil is based mainly on local resources of hydro, natural gas and a little lignite. The exception is North East Asia where nuclear power and imported coal are important.

The pattern of substitution past 2000 will probably change. Many countries will be approaching the limit of the hydroresources which they can easily develop. The undeveloped hydroresources of the region will still be vast, but apart from a few favorable placed countries, the resources will be remote from load centres and/or will require international collaboration. Further substantial contributions from hydro power will require large scale developments generally in an international context.

It is likely that there will be new discoveries of natural gas in the region. These must compensate for present consumption before they can support new power generation projects. A more conservative altitude to non renewable resources will probably develop.

In the longer term it is likely that the countries of the region will need to extend their sources of generation to include large volumes of imported coal and nuclear. The supply and conversion chains in both cases exhibit strong economies of scale; both have exceptionally long lead times. Both depend on collaboration with foreign suppliers and both may benefit from a degree of collaboration within the region. Decisions about how and when to implement these options and in what proportion will be complex and difficult. There is at present little debate of the future of electric power generation in the region in the long term. More debate about this matter would be beneficial.

/INTRODUCTION

INTRODUCTION

The ESCAP region contains about 55 per cent of the world's population is responsible for about 17 per cent of the consumption of commercial energy in the world and produces about 16 per cent of the world's electricity. Total generation in 1982 was 1355 TWh, 3 per cent greater than in 1981.

The ESCAP region is heterogenous. There are gross differences in size, national income, rate of economic growth, economic structure, resource endowment, geography and culture. The developed countries of ESCAP (Australia, Japan, New Zealand) contain 6 per cent of the population but consume 36 per cent of the commercial energy and produce 54 per cent of the electricity. Japan alone generates about as much electricity as the whole of developing ESCAP, including China. China in turn produces about as much electricity as the rest of developing ESCAP; India generates nearly one half of what is left. At the other end of the spectrum, the region contains many small utilities in islands and land locked countries. The ten smallest utilities of the region together produced just over 150 GWh of electricity in 1982; not much more than one ten thousandth of the total for the region.

TRENDS

Temporal growth

Figure 1 resumes the historic growth of power generation for some of the member countries of ESCAP, (1) These statistics, and the other time series used in this report, must be treated with caution. The records contain many inconsistencies apparently caused by redefinition of terms and to some extent by revised data on private generation. It is interesting to compare the time profiles of the various countries and groups. During the 1960's consumption increased at about 12 per cent per year in both developed and developing ESCAP countries, a little faster in the latter. A pronounced change in behaviour is evident in developed ESCAP countries starting in 1974. Growth is reestablished in 1975 at a lower rate; this pattern endures for a few years and is replaced in the late seventies and early eighties by a period of stagnation. Analogous effects can be detected in developing ESCAP countries, but they are delayed and less pronounced. The discontinuity in growth rate occurs in 1976; the degree is less; there are no periods of stagnation. The behaviour of the developed member countries is dominated by that of Japan, which produces some 85 per cent of the electricity in the group. Among the developing country members of ESCAP there are substantial variations. The largest contributor is China; her autarkic economy has been protected from the economic conditions affecting most other countries.

/The

The rate of growth of electricity generation in India fell off well before the first oil crisis; the late seventies have produced only slow growth. The profile for the developing ESCAP is largely the result of the quite different behaviours of China and India. The smaller developing countries tend to show fairly strong sustained growth with some faltering at the end of the period.

It is unwise to use these time series as predictors of future growth. There is no way of knowing whether past trends will be reestablished, whether present trends will be continued or whether a further decline in growth rates is yet to come. Simple extrapolation of past trends cannot be related to the underlying factors governing demand for electricity without some intermediate formulation of the appropriate relationships. This is an important observation because the time rate of growth is still wedely used within utilities for forecasting. Even in utilities which practice econometric modelling the final choice of demand forefast is generally made by senior management according to which results is consistent with their intuitive ideas about the time rate growth.

Electricity consumption and national production

Figure 2 shows the time trajectories for selected countries in the space of GDP per capita and electricity consumption per capita, (i). The caveat about the significance of the statistics must be repeated; the time series for national accounts are even more full of dangers than those for electricity generation. The trajectories are shown on a log/log plot. The result are interesting.

In many instances the trajectories fall closely along a common curve, i.e. for Japan, Singapore, South Korea, the Philippines and for the whole of developing ESCAP excluding China. The implication of this result is that countries with similar per capita national incomes consume similar quantities of electricity per capita regardless of the date at which they achieve that income and therefore of the technological structure and the relative prices of different goods and services. This is a surprising result. One would expect the greater availability of electricity in recent times to have caused higher volumes of electricity to be consumed for a given income level in countries reaching that income level at a later date. There is some sign that this is so; the Philippines lies to the right and below the Republic of South Korea which lies to the right and below Japan. The non conformity of the other trajectors to this hypothesis make it clear that other factors are also involved.

/Figure 1

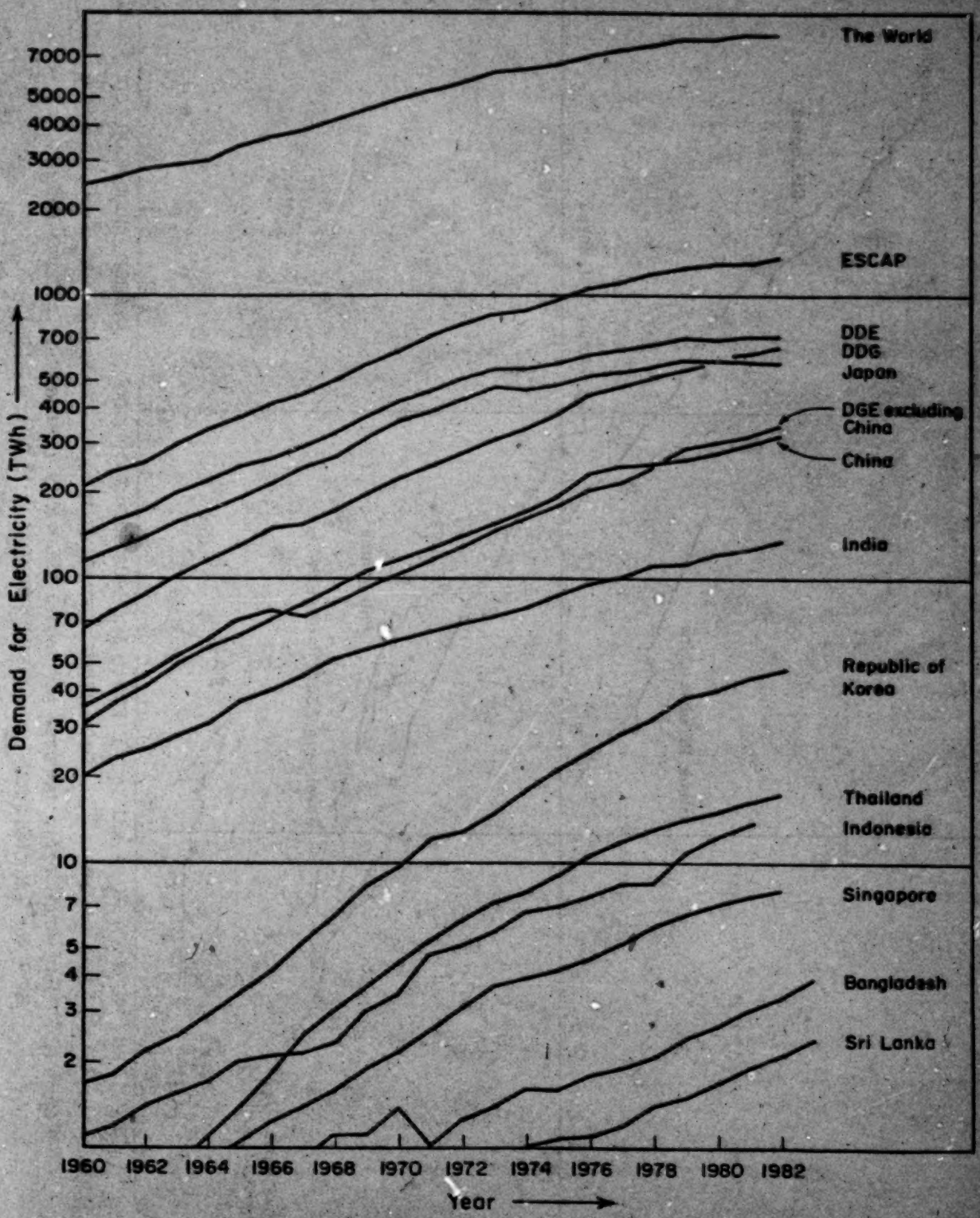

Figure 1 Growth in Demand for Electricity with Time.
DGE = Developing ESCAP; DDE = Developed ESCAP

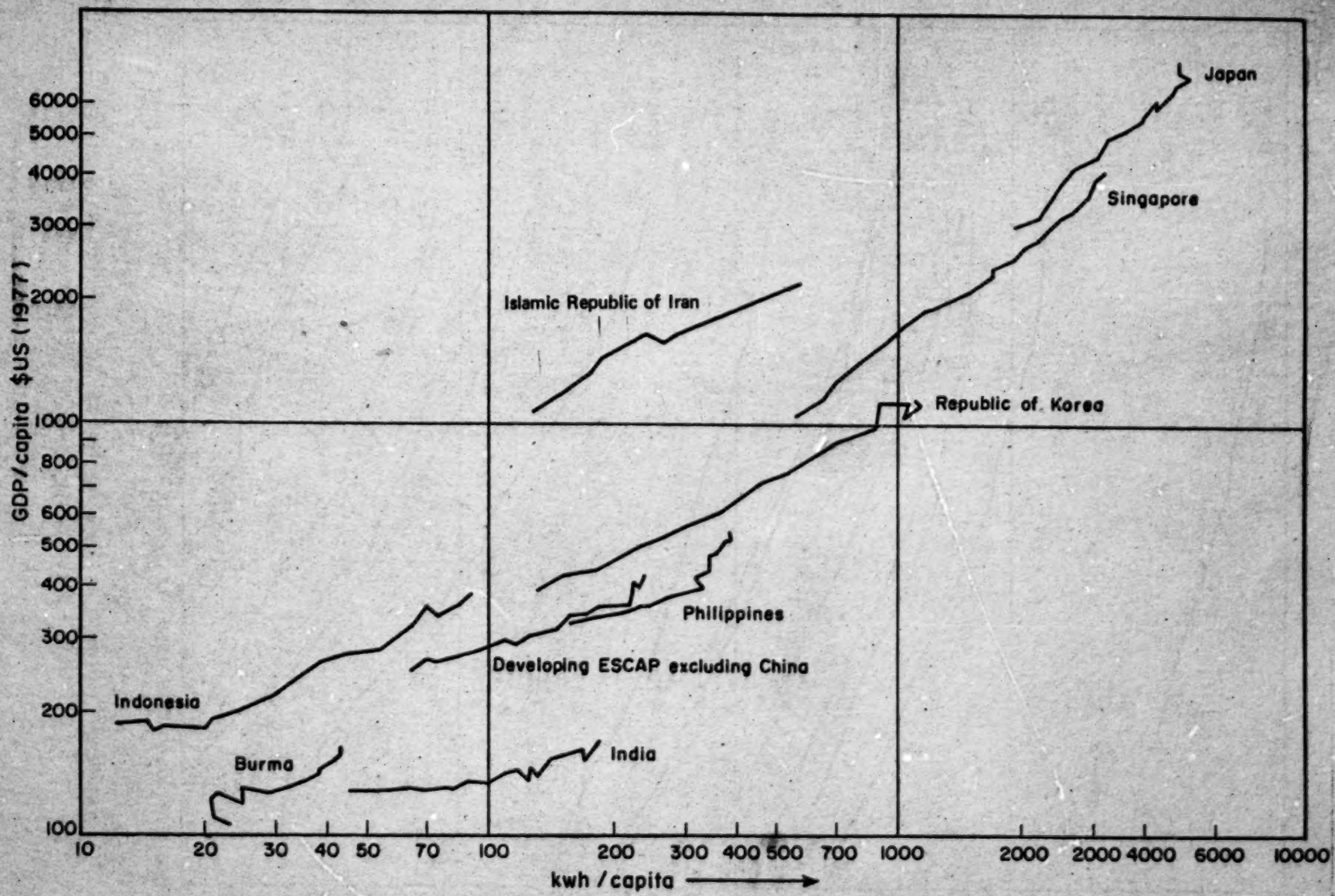

Figure 2 The Relationship between per capita electricity consumption and per capita GDP for selected countries. (1960–1982)

It is interesting to consider possible explanations for the non conforming nations. Plausible reasons can always be found for any exceptions so the following rationalisations may be treated with scepticism. The Islamic Republic of Iran shows a per capita generation well below that to be expected from her national income. During the period under consideration the Islamic Republic of Iran enjoyed considerable revenues from its oil production which were spent in large part on the import of investment and consumer goods. This consideration may explain its anomalous position. India in contrast shows a per capita generation well above that which might be expected from the national income. India has a socialist, planned economy with strong emphases on heavy industry and social welfare. Large industrial consumption and extensive rural access to electricity probably contribute to the displacement of India from the common curve.

Figure 2 also reveals how the marginal tendency to consume electricity falls with income. If the cluster of countries with similar trajectories is taken as a norm, then an increase of 1 per cent in GDP per capita around the $US 400 mark is associated with an increase of may be 1.5 per cent in kWh per capita. At around the $US 1000 mark a 1 per cent increase in GDP per capita causes a 1 per cent increase in electricity consumption; at the $US 3000 mark the ratio falls to about 0.8.

The time series of kWh per capita and income per capita and even the inter-country comparisons seem to imply a stable relationship between income and electricity consumption which could be used as a predictor of future electricity demand. There are not the marked discontinuities of gradient which characterise the temporal profiles. Rather the trajectories lie along a smooth curve.

There are at least two problems in using these relationships to predict future demand. First, it is necessary to predict GDP growth in order to proceed in this manner. Second, there is some distinctly erratic behaviour in the last few years which suggests that there has been a structural change in the relationship and that these curves may not simply be extrapolated. The first point is just inescapable; there is no sensible way of calculating demand for electricity which does not make an implicit or explicit assumption about future economic activity. The second point, concerning recent changes in the relationship between income and electricity consumption is conveniently represented in Figure 3 which shows, for selected countries, a plot of specific electricity per unit of national income, as a function of time,

(i) These curves give an indication of the manner in which recent events have, to varying extents in different countries, caused electricity to be substituted by other factors of production.

The curve for Japan shows a slow increase in specific electricity consumption during the sixties and early seventies followed by a steadily accelerating decline. It is the only country of those shown for which the specific consumption now is less than in 1965.

The behaviour shown by Japan may have important implications for the future trend in other countries of the region. Other countries may knowingly or unknowingly import part of this structural adjustment. Many appliances in use in the region are made in Japan or designed on Japanese models; some of the process technology being installed comes from Japan. The quantitative consequences are difficult to assess, but the qualitative implication should be acknowledged.

The developing countries all show rapidly increasing specific consumption in the early part of the period. There is considerable variation in the manner in which the countries have adapted to the conditions of the 1970's. The Republic of Korea shows almost no change in its rapid rise of specific electricity consumption until recently. The plot in figure 3 is logarithmic so the almost straight line characterising the Republic of Korea indicates a steady exponential increase in specific energy consumption over twenty years; this is remarkable. All other countries show signs of adjustment. In the Philippines the major change in the historic relationship occurs around 1973; there is a discontinous change from a rapidly increasing specific consumption to one on which decreases steadily and significantly. Thailand shows a smoother adjustment reaching a steady value. India is similar. The curve for developing ESCAP excluding China is irregular but shows a steady, if not falling, specific consumption after 1976. Singapore exhibits a marked but late adjustment.

Figure 3 shows an important change in the historic relationship between output and electricity consumption; there has been in all countries some adjustment to higher electricity prices and a consequent reversal of the historic tendency for electricity to substitute for other factors of production. The figure also shows that some countries have been significantly more successful than others in adjusting to changed conditions.

There can be no doubt that the historic trend for electricity to replace other factors of production has been disturbed in recent years.

/Figure 3

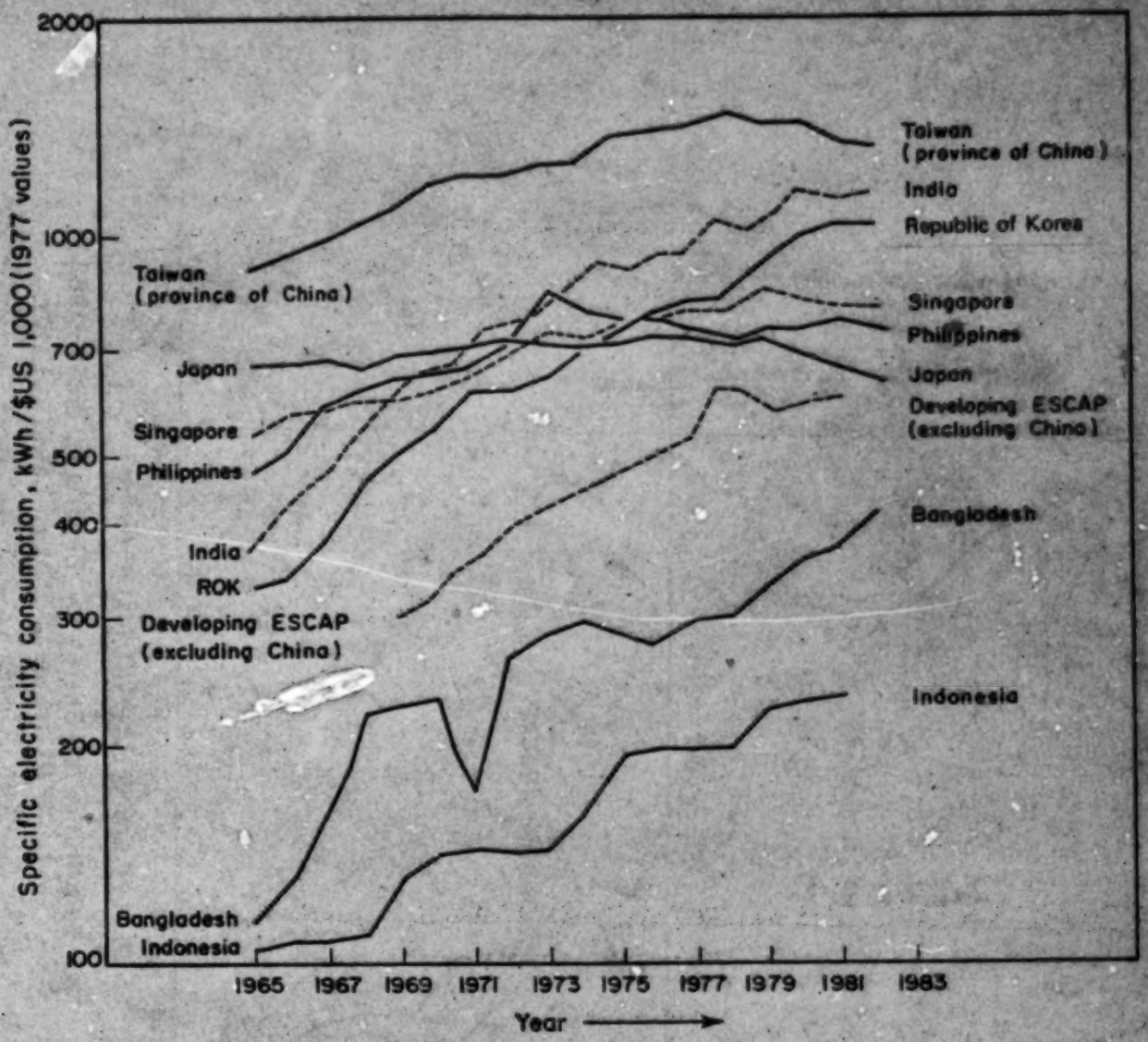

Figure 3 Temporal trend of the specific electricity consumption in selected countries.

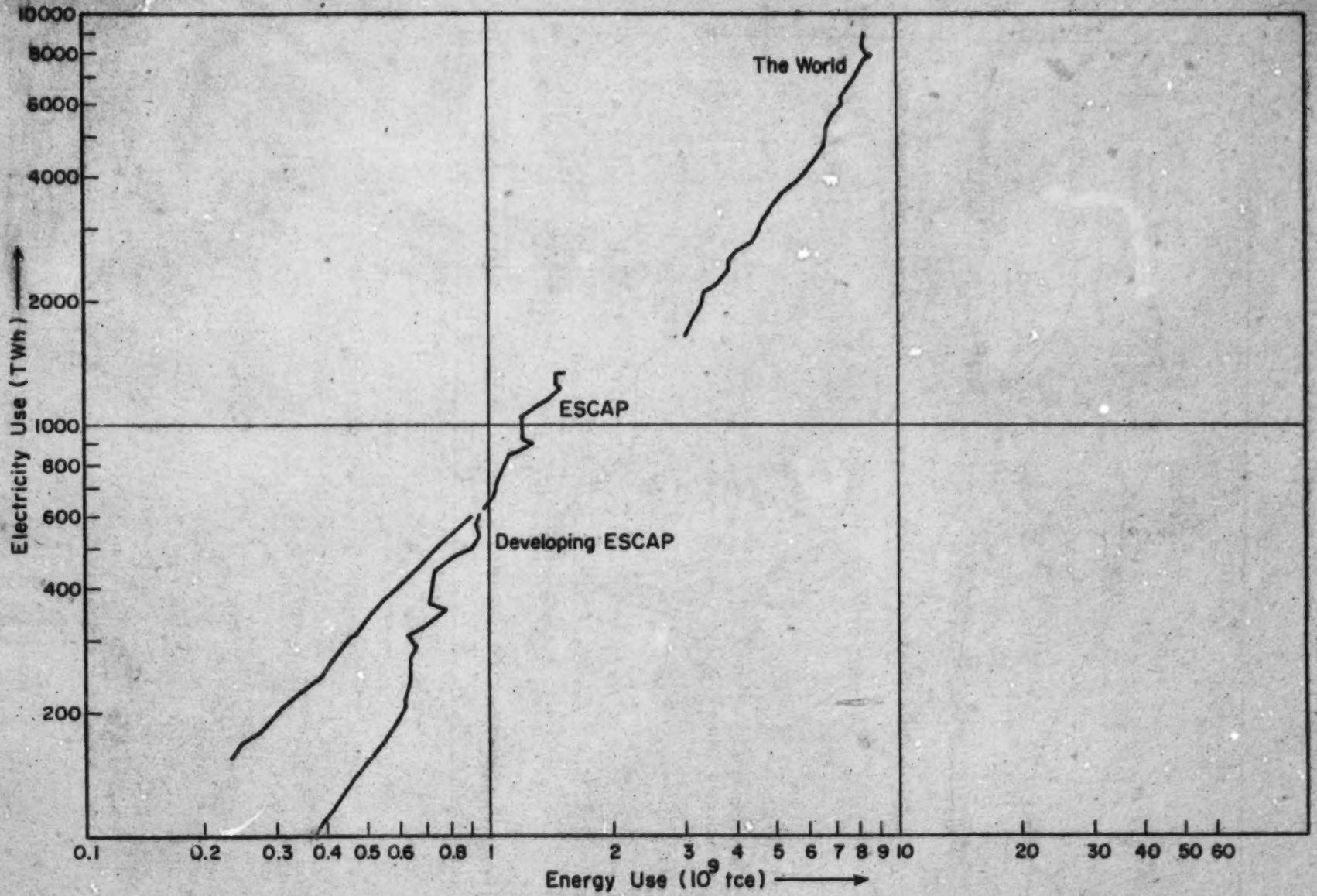

Figure 4 The Substitution of Energy by Electricity. (1955–1982)

It is also useful to know in particular whether there is any tendency for electricty to substitute for other fuels. This is important for policy formulation because it governs the extent to which the electricity system can be used as an indirect means of substituting other fuels for oil. Figure 4 shows time trajectories of the use of electricity and commercial energy in a log/log space. Plots are shown for the world, for the ESCAP region and for developing ESCAP countries (i).

The plots are from 1955 to 1982. They have to be interpreted with care because the time series for energy use contain frequent revisions of definition. To a first approximation the trajectories are all straight lines. Those for the world and for developing ESCAP countries have average gradients greater than unity, indicating a continuous tendency for electricity to be substituted for commercial energy. The early portion of the trajectory for the ESCAP region has a gradient of about unity, indicating that commercial energy use and electricity consumption have grown at similar rates with no tendency to substitution.

In all three trajectories the gradients become steeper in later years. This behaviour suggests a strengthening tendency for electricity to substitute for commercial energy.

Variations in Specific Electricity Consumption

It is also of interest why the specific electricity consumptions shown in figure 3 vary so much from country to country. The reasons are complex. The specific consumptions show no significant correlation with GDP; i.e. there is no systematic tendency for wealthier countries to have more or less electricity intensive economies. There is also no apparent correlation with the percentage of national production arising from agriculture or industry. There is some correlation with the percentage of the population which has access to electricity. A scatter diagram of the two parameters in a log-log form is shown in figure 5, (i).

A plausible model relating demand for electricity to the percentage of the population connected, might be

$$\text{kWh per capita} = \text{constant} \times (\text{GDP per capita})^{a} \times (\text{percentage connected})^{b}$$

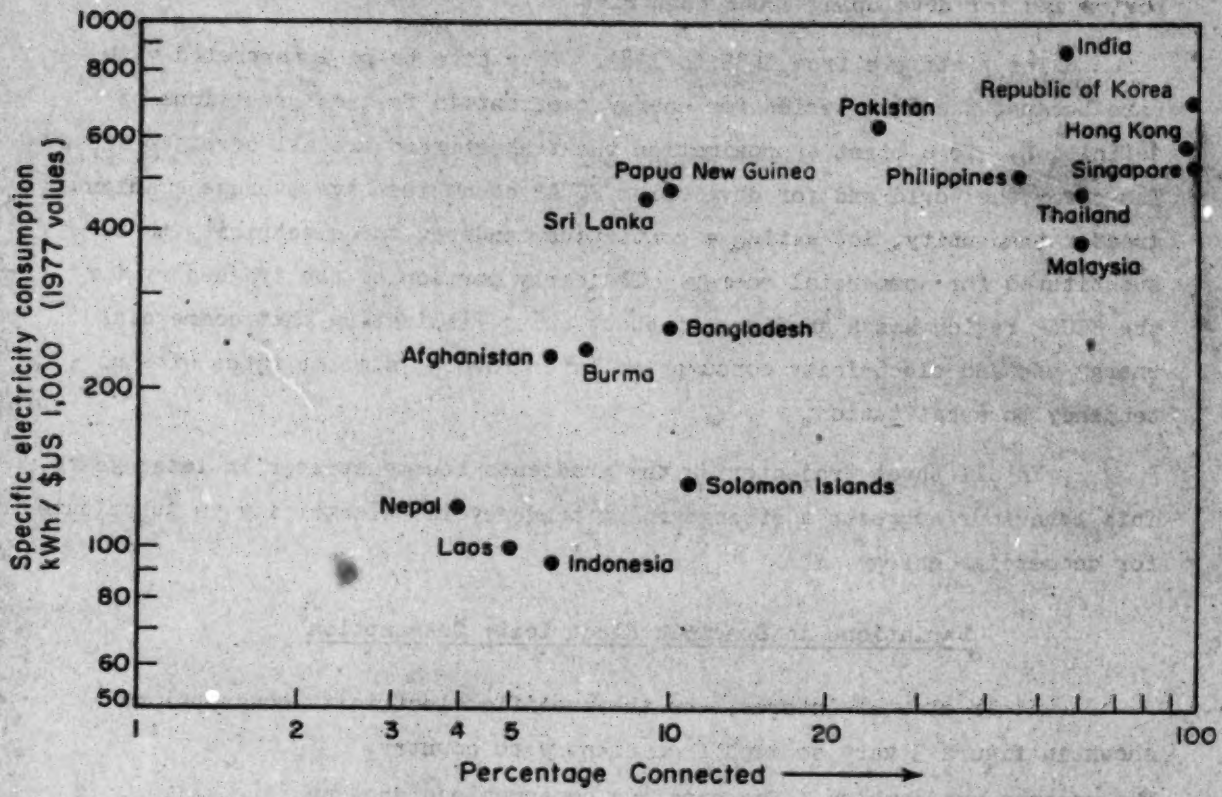

Figure 5 Specific Energy Consumption as a Function of the Percentage of Population Connected

This model implies that consumption is related to income by an elasticity a and also to the fraction of the population b who have direct access to electricity. The parameter b should be less than unity, partly because everyone consumes electricity indirectly, whether they are connected or not and partly because it is likely that larger consumers will be connected first.

Regression of this model shows b to have a value of about 0.6 and to be much more significant than a.

It would be wrong to give too much attention to this simple analysis, but the results are interesting and suggestive. If the model is believed then it does emphasise the importance of suppressed demand in helping to determine consumption.

To summarise this section:

- the time trends of electricity consumption are not good predictors of the future
- the relationship between per capita income and per capita consumption of electricity shows considerable regularity in time and some consistency in cross country comparisons. There is generally erratic behaviour in the last few years
- there is evidence of a substantial adjustment to higher prices for electricity in the specific energy consumptions after about 1975
- there is evidence of significant disturbance in the process of substitution of electricity for fuel which has been going on for many years.

The analyses presented in this paper are simple. There could be some merit in an extensive analysis of pooled time series and cross sectional data for the region with the objective of giving better insight into the historical determinants of electricity consumption.

/STRUCTURAL

STRUCTURAL ADJUSTMENT WITHIN THE POWER SECTOR

The substantial increases in the price of fuels, and of oil products in particular, would be expected to have a substantial influence on the optimal design and management of power systems. Adjustment might be anticipated in

- the optimal structure of generating plant and in particular on the amount of oil burnt
- the optimal balance between capital expenditure and efficiency in matters such as losses in auxiliary plant and in transmission and distribution
- the benefits to be obtained from more detailed and precise load despatching under control of computers
- the proper nature of the economic and physical relationships between the power system and the world outside, e.g. in tariff levels and in the extent of load management.

The matters will be taken separately.

The transition from oil

The rise in price of oil relative to other fuels decreases the attraction of oil generation relative to other options. There are many alternative forms of generation; the appropriate substitute depends on the circumstances of the particular country. The patterns of adjustment vary considerably from country to country depending upon whether the nature of the power system lends itself to immediate substitution of oil and on what factors govern the choice of new investment.

Power systems which contain a mix of thermal generating plants operating on oil and other fuels are able to adjust rapidly to changes in relative fuel prices by changing the order of despatching of plants. This rapid adjustment was not possible for most utilities in the ESCAP region. The power systems in many member countries comprise oil and hydro plants, the despatch of which was laready scheduled to minimise the oil burn. In other cases the extent to which the emphasis of the fuel mix could be shifted away from oil was small, either because there was little generating capacity operating on other fuels or because the generating capacity which did exist was dependent upon limited supplies of local fuel.

/Adjustment

Adjustment to the new oil prices has therefore mainly come from the commissioning of new plant. The effects are long in developing. Plans had been laid on the assumption that there would be no change in relative fuel prices important enough to disturb the ranking of alternative means of power generation. Consequently large volumes of oil fired plants were being built in the late sixties and early seventies. In several member countries the amount of oil burnt increased substantially as plant was commissioned which had been ordered in different circumstances. The prospection for, the delineation and development of indigenous natural resources takes many years. The introduction of plant burning imported coal or nuclear fuel also requires lengthy planning and appraisal.

These constraints on the rate of substitution of oil by revised operating procedures and new investments have considerably delayed the appearance of significant changes in the composition of the mix of fuels used for generation. Substantial changes are now beginning to appear. Figure 6 shows the historic and expected future composition of the generation from the utilities in Thailand and the Philippines. The figure shows how the adjustment to new circumstances has taken a long time to appear. One may doubt whether the development of alternative forms of generation will proceed quite as fast as the utilities plan, but it is the case that little of the plant ordered since 1973 in the ESCAP region is obliged to burn fuel oil. The effects of this shift in emphasis in newly commissioned plant will accummulate rapidly to the end of the decade.

Table 1 attempts to summarise the dependence of the developing countries of the region on oil products for power generation in 1980 and 1990, (1).

/Figure 6.

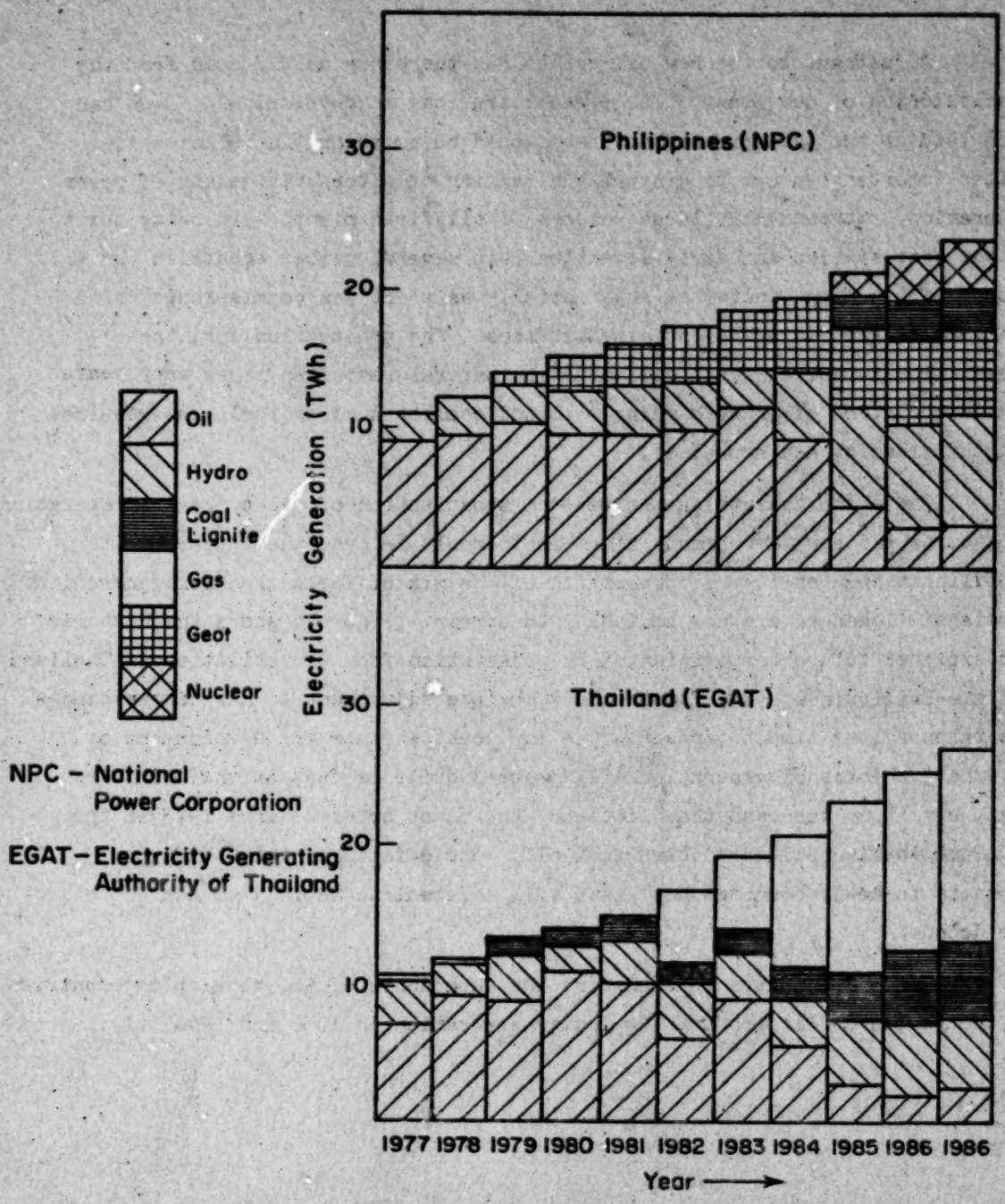

Figure 6 The Transition from Oil in Two Utilities

Table 1. The Percentage of Electricity Generated from Oil Products in 1980 and 1990 for Selected Countries of the ESCAP Region. (Entries for 1990 are indications, not firm forecasts.)

Country	1980 percentage	1990 percentage
Afghanistan	28	NA
China (Taiwan Province)	60	10
Hong Kong	100	20
India	7	5
Indonesia	82	35
Iran (Islamic Republic of)	47	NA
Malaysia	84	25
Pakistan	2	10
Philippines	51	10
Republic of Korea	73	10
Singapore	100	100
Sri Lanka	8	5
Thailand	71	20
Average	38	14
Average without India	62	21

The figures for 1980 show the wide variation in the extent of oil dependence. Overall the dependence of the developing countries of the region is modest, between 30 and 40 per cent. This is because the statistics are dominated by India, where little oil is burnt. Excluding India the dependence on oil is significant, over 60 per cent.

The estimates given for 1990 are based on utility figures, but have in most instances been modified to allow for the probability that the extent of substitution will be less than planned. Projects are more commonly late than early and more commonly fall below, rather than exceed, the expected capacity.

The general considerations which govern the future oil burn in the developing member countries are resumed briefly.

/East Asia

East Asia is likely to make a substantial transition from oil both in percentage terms and in volume. The developing country members of this group are the Republic of Korea, Hong Kong and Taiwan Province of China. Japan must also be considered because the scale of the substitution for oil in Japan will have consequences for the region. Substitution will come mainly from coal (all four countries) and nuclear (Japan, the Republic of Korea, Taiwan province of China), with help from hydro (Japan and Taiwan province of China) and natural gas (Japan, possibly the Republic of Korea). It is difficult to estimate the numerical implications for the dependence on oil. Oil will be the marginal fuel and will absorb most of the discrepancies between the planned condition for 1990 and the eventual outcome. The figures given in the Table 1 are only indicative.

Percentage measures of substitution are not enough. A smaller percentage of a much larger future total of generation can imply a higher dependence on oil measured by volume. This will not be the case in East Asia. The reduction in the consumption of fuel oil for power generation is likely to be 20-30 million tonnes a year by 1990.

The countries of South East Asia are heavily dependent on oil for electricity. This group comprises Thailand, the Philippines, Malaysia, Singapore and Indonesia. Thailand has an ambitious programme of substitution based on new hydro capacity, gas fired combined cycles and lignite. It is planned to reduce the oil burn to 9 per cent by 1987. In practice there have been difficulties with the gas and future supplies are unlikely to appear as rapidly as the expansion plan proposes. The indigenous lignite is deep. Delays and short falls are likely there also. Environmental concern has delayed the proposed barrage at Nam Chon on the Upper River Quae Yai; this will affect system plans after 1989. The forecasts by the utility may be optimistic. An oil burn in 1990 equal to 20 per cent of the generation mix may be more likely. This percentage would be roughly equivalent to the volume of oil burnt in 1982 or half that burnt in 1980.

The Philippines has an extensive programme of substitution by coal, hydro, nuclear and geothermal. The effect of this has already been felt; the share of oil based generation fell from 83 per cent in 1973 to 58 per cent in 1982. In the next ten years it is planned to add nearly 2000 MW of new hydro plant, 1660 MW of coal fired capacity, 670 MW of geothermal and to commission the 620 MW nuclear set presently under construction. Apart from a small addition of diesel capacity no new oil burning plant is planned.

/If

If fully implemented the expansion plan would reduce the share of oil in generation to a few per cent by 1990. There will probably be slippages in commissioning, but it is also possible that the demand forecasts are too high. In any event the oil burn will be much reduced from the 1980 level; probably to 10 per cent or less.

In Malaysia the effective capacity of oil fired plant will be reduced by the conversion of 840 MW of plant at Pasir Gudang and Port Dickson from oil firing to gas firing. 900 MW of gas fired combined cycle plant at Paka should be commissioned by 1986. A 300 MW coal fired thermal unit should be commissioned in 1985. In the longer term the government plans to pipe gas from the east cost to the west coast in order to reduce dependence on oil for electricity generation. Beyond 1990 there is the attractive possibility of developing the hydro resource in Sarawak, known as the Pelagus Rapids Hydro Electric Development. There is a potential of several thousands of megawatts which could be absorbed by Malaysia and Singapore. The conversion of the oil fired plant to gas firing should reduce the volume of oil burnt considerably, depending upon the availability of gas. Providing gas is available to support gas firing on the thermal plant the proportion of oil in the generation mix could fall by 1990 to about 20 to 25 per cent. Consumption by volume could be about half the present.

Indonesia has abundant reserves of indigenous energy in oil, natural gas, coal, hydro and geothermal. The oil and gas are fairly independent. There is little gas associated with the oil fields. The deposits of dry gas in North Sumatra and the South China Sea are remote from population centres. Despite the large reserves gas tends not to be an economic choice for power generation. The gas turbines presently operating in Java burn light oil products. Hydro electric resources are large but again, they are remote from centres of demand. There is estimated to be 78,000 MW of potential, of which only 1350 MW have been developed. Only a few per cent of this is in Java; by far the largest part is in Kalimantan, Irian Java, Sumatra and Sulawesi. Indonesia also has large coal reserves; development has been slow and arduous. Coal fired plant presently in construction is likely to be ready before the coal supplies. Indonesia has large geothermal fields; small units are presently producing; a substantial contribution to power generation is expected after 1990.

/Expansion

Expansion plans up to 1990 for Java envisage additions of about 1000 MW of oil fired steam capacity plus large additions of hydro and coal. After 1990 it is hoped to reduce the oil fired plant; very large additions of hydro and coal are expected after 1990. Outside Java capacity additions will come from coal, hydro and a big programme of diesel. Large projects in remote areas are vulnerable to delays, some slippage from the schedule of implementation may occur. It is likely that in any event there will be a large increase in the consumption of oil. In 1990 the oil burn will probably be double that of 1980, although the percentage of units generated from oil will fall to between 30 and 40 per cent.

Singapore presently generates electricity exclusively from fuel oil. All definite extensions to generating capacity will be oil fired. Its own refineries are not at present able to supply the necessary residual oil and the deficit is imported. Coal has been carefully examined as an alternative fuel but rejected for the time being because of the environmental implications for a small, densely populated island. Gas may be brought to Singapore from Malaysia. In that event the power station at Senoko could be converted; the new station at Pulan Seraya will be designed for dual firing. It is unlikely that gas will be available before 1990. Oil consumption will therefore increase in proportion to electricity generated.

The total effect of these shifts within the South East Asian countries will be to reduce the total of oil burnt for power generation by a small amount, may be by about 1 million tonnes per year. As a percentage of units generated the importance of oil will decline rapidly. There will be geographical shifts and some greater emphasis on light products.

South and Central Asia, with the exception of Iran, presently burns little oil for power generation. This group of countries includes Bangladesh, Nepal, India, Sri Lanka, Pakistan, Afghanistan and the Islamic Republic of Iran. The power development plan for India is based on coal stations located at mine mouths, Hydro and nuclear. Little oil is burnt for power generation and this situation is likely to continue. There is a large suppressed demand which cannot be satisfied because the generating plants are not reliable. Generation is also sometimes constrained by the rate of supply of fuel. These problems are unlikely quickly to be resolved; they may get worse if the large mining projects which are required to support the planned coal fired power stations should be delayed. If the quality of supply does not improve then industry may be permitted to build more captive power plants. These could well burn oil. The effect on the fuel oil market internationally is unlikely to be dramatic.

/Sri Lanka

Sri Lanka has recently developed a large part of her hydro resources; the economic potential is now largely exhausted. Incremental generation will probably come from coal fired stations on the coast at Trincomalee in the North East of the island. Neither the implementation nor the timing of this project is yet certain.

Pakistan has substantial reserves of gas which until recently were planned to be a principal feedstock for future power generation. The attitude within the country has lately changed. It is now planned to stop burning gas in power stations after 1985, with the exception of the combined cycle plant at Guddu. There is some local coal and substantial undeveloped hydro potential. The coal is of poor quality and the known reserves will not support more than about 5000 MW of generation. The hydro capacity is becoming more expensive to develop. Even so, it will be the main component of long term expansion. In the intervening period it is likely to be necessary to build new oil fired plant.

Bangladesh has reserves of gas which are large in comparison with its economy. These will provide an adequate basis for power generation for sometime to come, but it is not clear what will be the source of incremental generation after 1990. It may be that reserves are being depleted too fast. Proper pricing policies for non-renewable resources need to be promoted.

Nepal has enormous reserves of hydro power. There are technical difficulties; the rock is often poor and siltation is heavy; access is hard. Development of the sites would be expensive. Efficient utilisation of the resource demands much larger generating capacity than can be absorbed in Nepal alone; it is desirable that neighbouring countries collaborate in the development of the resource.

Afghanistan has large reserves of gas and hydro; the substitution of oil in power generation faces no technical problem.

The Islamic Republic of Iran has large reserves of oil and gas. All fossil power stations in Iran can operate on oil or gas. One plant at Zarand can burn coal also. Because the export of oil is easier and more profitable than the export of natural gas it is probable that Iran will progressively substitute oil fired generation by gas.

/The

The figures for 1990 given in Table 1 are meant only as approximate indications; they suggest that the proportional dependence on oil for power generation in the member countries will drop rapidly to about 14 per cent, including India or to 20 per cent excluding India. The volume of oil burnt will probably also fall, may be by some 30 million tonnes. It is likely that demand in the region for light oil products, for purposes other than power generation, will increase. The production of virgin residual oil will increase accordingly, further disturbing the balance of the oil product market. Upgrading capacity will be built to convert some of the virgin residual fuel oil to light products and cracked residual fuel oil, which cannot be further processed. It is not clear yet where prices will settle. There is likely to be some weakening of the relative prices of heavy products. This may restrain some of the substitution of oil.

System Losses

Figure 7 shows actual and forecast losses for selected utilities over a ten year period, (2). Electricity is lost in auxiliary consumption, in Joulean heating in transmission and distribution and in non technical losses, including theft. The figure shows that there is no clear historic tendency for losses to diminish with time. In some countries the proportion of electricity lost has risen over the period. The future trend is characterised by good intentions among the countries with high losses and relatively little change among the others.

It is hard to interpret a comparison of the level of losses on different systems. There are many influences. Losses in auxiliaries and losses in transmission and distribution are determined by different factors. The proportion of electricity which is lost in auxiliaries depends on the structure of the generating system, in particular the split between hydro and thermal plant. Hydro plants require less electricity to run than do thermal plant. Among thermal plants, coal fired units have higher losses than oil fired plants because of the need to handle and prepare the coal. the cooling system employed also affects the consumption of auxiliaries. A simple comparison is therefore of little significance. However, an attempt has been made in Figure 8 to show the influence of hydropower in consumption by auxiliaries.

/Figure 7

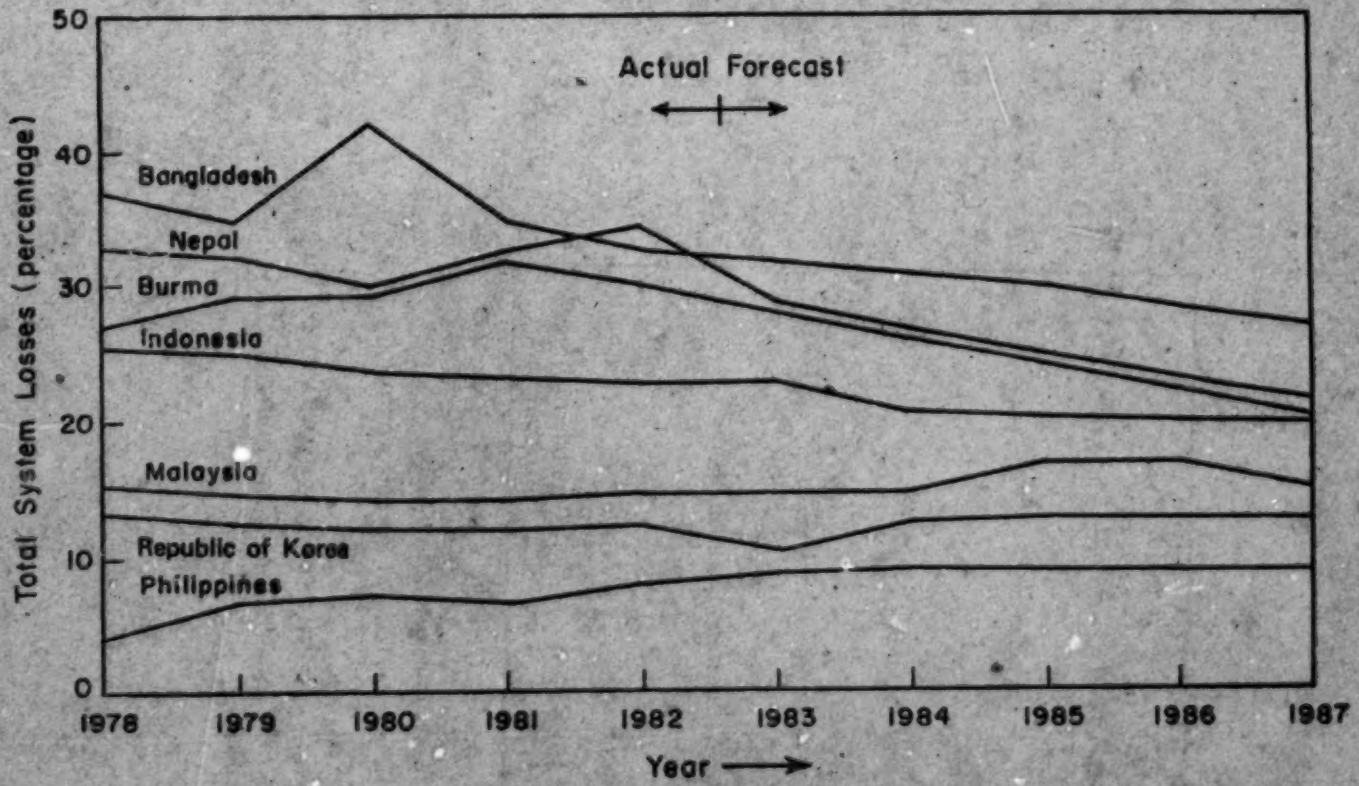

Figure 7 The historical and future system losses for selected countries.

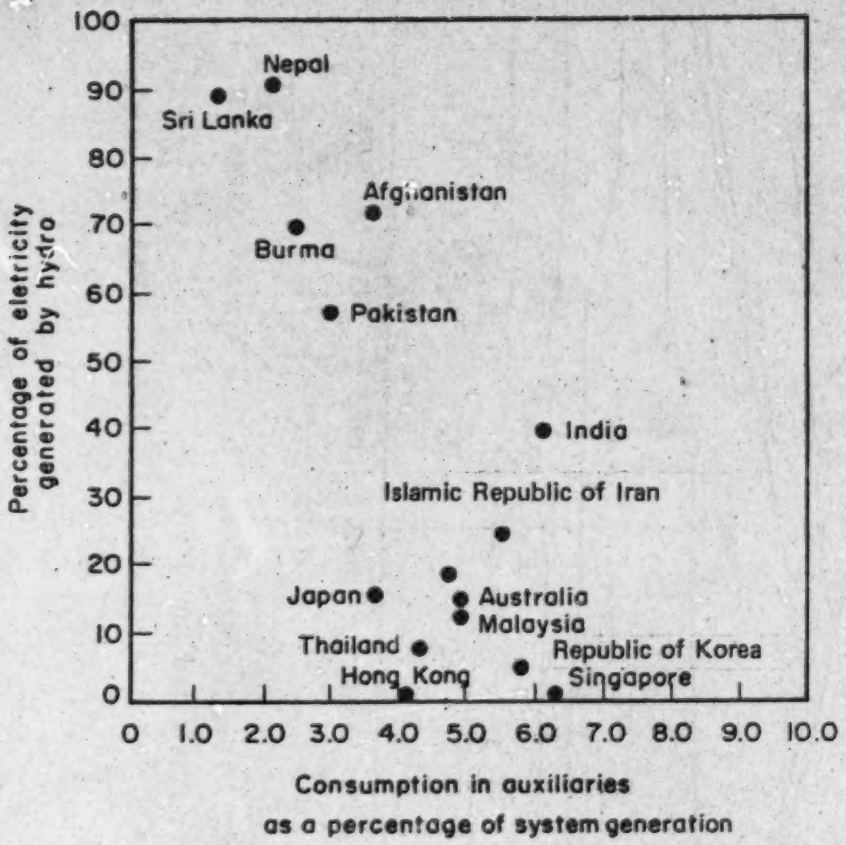

Figure 8 The losses in auxiliaries as a function of the percentage of generation from hydro.

Losses in transmission and distribution (T and D) vary more from system to system than do losses in auxiliaries. It is tempting to conclude that power systems with high losses in T and D are less well designed than those with low losses. The temptation should be resisted. The design of a single power line can be optimized to find the best balance between Joulean losses and capital expenditure. With simple, but reasonable, assumptions the calculation suggests that the percentage of losses should vary as the inverse square root of the power transferred. It follows, and indeed is obvious, that the optimal loss level will tend to be higher for systems where the power transfers are lower. Dispersed systems with low maximum demands will have higher optimal loss levels than concentrated systems with high maximum demands. There is no parameter which well represents this degree of dispersion combined with intensity of power flows. An approximate measure is the per capita generation. The calculation cited above implies that a log-log plot of the proportion of losses against the per capita generation should give a straight line. This is roughly true as is shown in Figure 9.

The implication of the Figure 9 is that there is more homogeneity in the performance of systems than at first appears. Distribution and transmission networks are designed to common standards and this is revealed in the figure. The figure almost certainly exaggerates the case. Utilities which experience capital stringency overload all components of the power system. High loss levels in distribution are the analogue of poor reliability in generation.

Poor maintenance and planning contribute to high loss levels. Distribution system planning is often limited to a short period, typically three years or so. This is not adequate especially when the load grows rapidly. It leads to overloading, ad hoc extensions and expensive replacements. Longer term planning using modern computer programmes would be beneficial in some countries.

Even if there is rather more similarity in the performance of networks than is generally supposed, this should not detract from the fact that the level of losses is too high. A World Bank study has shown that the design rules commonly used for sizing transformers and conductors do not properly reflect the true cost of electricity lost, (3). Losses in distribution not only require extra fuel to be burnt, but also require extra generating

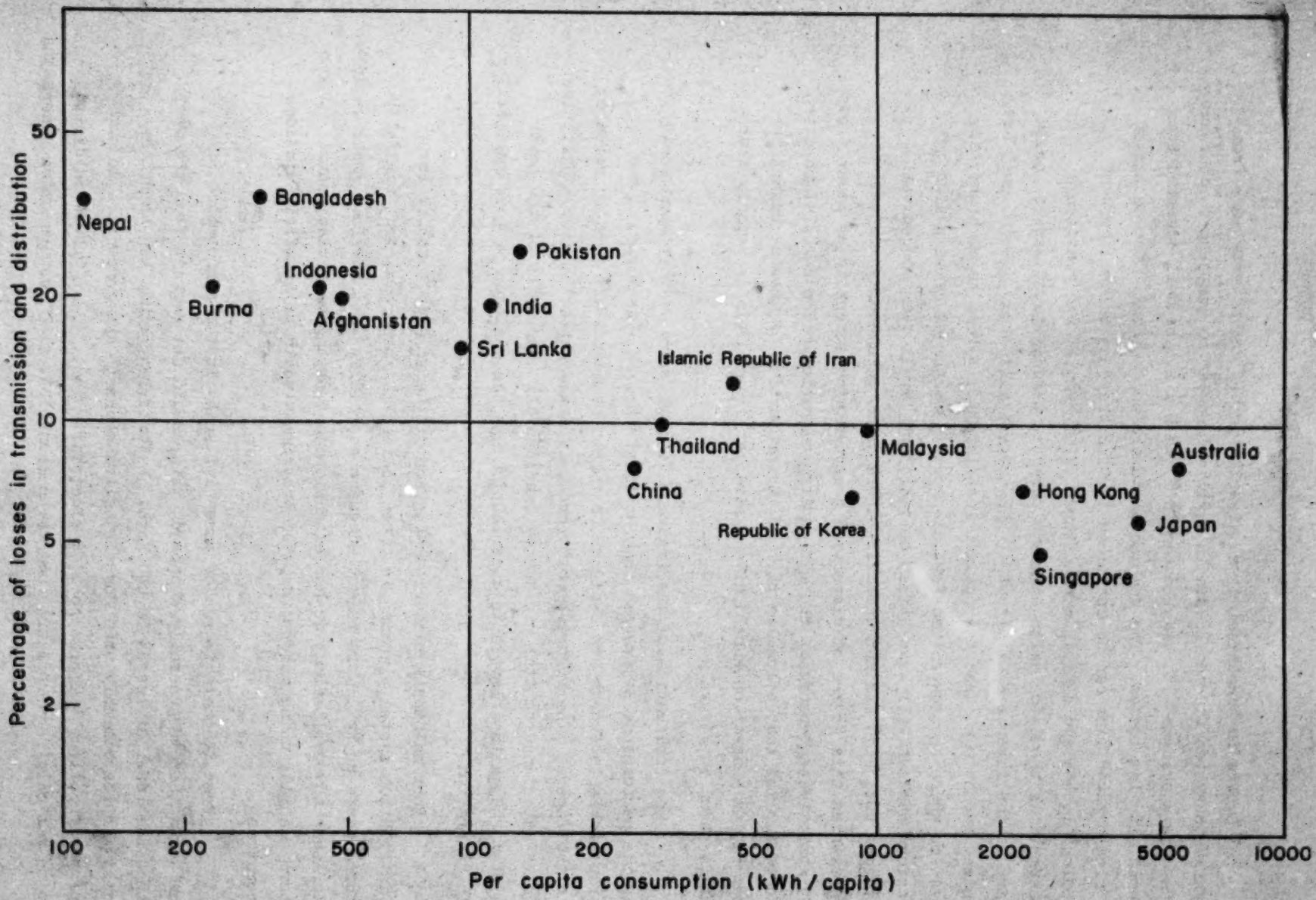

Figure 9 A Scatter diagram of the percentage of losses in transmission and distribution against the consumption of electricity per capita.

capacity to be installed. If these costs are properly introduced into design calculations then the appropriate design of networks give considerably lower levels of loss than are normally found. The rate of return from installing shunt capacitors is often extremely high because of the substantial capacity savings.

Joulean losses depend on the square of the current; they are therefore proportionally more important at peak times. It is peak demand which determines the requirement for generating capacity. A loss of 20 per cent of units in distribution averaged over the year could mean that 30 per cent of the generating capacity at peak is making up losses. The World Bank study concludes that in most cases it is cheaper to increase effective capacity by reducing losses than by building new plants. The assertions of the general study of the problem by the World Bank have been confirmed in a detailed study of one of the ESCAP developing member countries.

Despite general agreement that the level of losses in the power systems of the region could be reduced the implementation of programmes to reduce losses has been slow. Most countries are still at the stage of preliminary investigation and preparatory studies to develop methodologies to identify improvements. This is a topic on which a more sustained effort could be rewarding.

Load Despatching and Control

Automated analysis and control of power systems allows a more effective use of plant than mannual operation. Utilities benefit by lower system costs and higher reliability. The utilities of the region are at different stages in the implementation of automatic control. A few of the smaller utilities have no computer either on or offline. Others make extensive applications of computers on and offline.

High costs of fuel do in principle offer some encouragement to automation because the savings are correspondingly high; it is doubtful if in practice this consideration has any influence. The increasing interest in automation is caused by the falling prices of computer installations and readily available software. Many utilities in the industrialised world give their programmes to developing utilities for nominal payment.

/Despite

Despite these favourable factors the smaller utilities have not generally implemented computer techniques as rapidly as might be expected. One reason is a shortage of skilled personnel. Computer skills are in strong demand in many sectors of the economy; suitable people are not always available. Utilities may have the resources to train appropriate staff, but these are then lost either to private industry or abroad. Most utilities are government owned and may not be able to pay competitive salaries. This makes it hard to recruit and retain all types of personnel, but the difficulties are especially acute for novel skills and those in high demand.

The immediate benefits from computerized control may not always be as great as expected. The constraints on the operation of power systems in developing countries can be so severe that there is often almost no choice of mode. In this case the optimisation of operation is superfluous. It can also be the case that much of the information required for a computer application is not available in the utility. For example, if power plants are poorly maintained and their performance deteriorates then the incremental cost curves of the plant may not be known and it will not be possible to use an incremental cost method of load despatching.

Tariffs and Load Management

The adjustment of a utility to changing circumstances inevitably induces changes in the relationship of the utility to its customers. The most important element of this relationship is the tariff. A secondary element is the management of load by physical signals or prior agreements.

Tariffs are normally related to the financial and economic structure of a utility by accounting principles, by long run marginal costs or by a mixture of the two. The usual requirements of accountancy are:

- that revenues should cover operating expenses
- that the utility should achieve an adequate rate of return on assets
- that the utility should finance an acceptable proportion of its investments.

The order in which these requirements are listed is the normal order of the severity of the constraint in the conditions which presently prevail.

Performance by these criteria is erratic. Table 2 lists the operating ratios, return on assets and self financing ratios for selected utilities, (2).

/Table 2.

Table 2. The Operating Ratio. Return on Assets (Historical and Revalued) and Self Financing Ratios for Selected Utilities (1982)

	OR	ROR		SFR
	(percentage)	historical (percentage)	revalued (percentage)	(percentage)
Bangladesh	119	-4.5	na	-9.3
Burma	63	5.5	na	na
Indonesia	88	3.9	na	21
Republic of Korea	69	na	4.9	39
Malaysia	87	8.1	na	20
Nepal	100	-0.1	na	4
Pakistan (KESC)	75	15.3	na	25
Philippines	81	na	4.0	11
Sri Lanka	69	11.8	na	43
Thailand	80	19.1	11.5	35

Few of the utilities listed show an adequate rate of return on revalued assets. The Table 2 is far from complete but the figures given are probably typical of the region. The investments made in expanding power systems can be a substantial fraction of total capital formation in a national economy, up to ten per cent. Low rates of return imply that the investments might be better employed elsewhere. The situation is exacerbated by a tendency to support electric utilities through subsidies. Heavy fuel oil may be openly subsidised or indigenous fuels may be transferred to the utility at prices below the opportunity cost.

Accounting principles determine the requirement for revenue; they leave considerable scope for judgement on tariff structures and for discrimination among consumer groups. There is a substantial body of opinion among economists that tariffs should take heed of the long run marginal costs of supplying electricity. Under present conditions such tariffs ensure that revenues cover costs and that the utility achieves an adequate rate of return on assests. Whether long run marginal cost tariffs allow the finance of an acceptable proportion of future investment depends on

/the

the physical and financial system characteristics, the financial discount rate and the rate of growth of demand for electricity. Slow growth and a high discount rate lead to strong self financial possibilities; high growth and low discount rates give the reverse.

Long run marginal cost pricing requires not only that the general level of revenues be comparable with the costs of expanding the system, but also that rate schedules reflect the marginal cost structure at different voltages and times of day. In principle these tariffs give accurate signals to consumers and avoid cross subsidisation. In practice the process of transition from a marginal cost structure, even if known, to a schedule of rates limits the precision of tariffs and introduces scope for judgement or obfuscation, depending on the point of view.

Long run marginal cost studies have been made for almost all countries in the region, the results have had negligible influence on the overall level of electricity prices; they have made some impression on the design of tariffs.

Prices close to long run marginal costs would generate revenues for most utilities well in excess of costs, including a provision for self finance. This causes no theoretical problem but would not be popular. Pricing is, without exception among ESCAP members, subject to political control. Political priorities tend to be consistent with low prices. Low prices lead to high demand, difficulty in financing expansion in generation and transmission, poor financial performance, skimping in training and maintenance, poor availability of plant, poor reliability, overloading of networks and poor morale. Price increases are often precipitated by covenants introduced by international lending agencies into the conditions governing loans to utilities.

Low prices for electricity are often predicated as subsidies to the poor. There is much to be said about this on both sides. The cost of electricity is rarely a large part of expenditure for poor people. The ability to pay of some groups may be considerably higher than is acknowledged. A doubling of the price of electricity in Pakistan to domestic consumers of 600 kWh or more per month had no perceptible effect on domestic demand.

/It

It is unlikely that long run marginal cost studies will have any greater influence on the general level of electricity prices in the future. They will continue to be governed by the conflicting demands of politics and accountancy. It is more likely that these studies will influence the structure of tariffs, although there is but little evidence of this so far. A common means of charging reasonably large consumers is the kW related block tariff. This form of tariff is designed to recover costs equitably according to certain gross assumptions about consumer behaviour; they give quite the wrong signals to consumers about the marginal costs of consumption; sometimes they have implications at variance with the publically stated policy of the enterprise towards pricing. This situation arises because of a preoccupation with the average rather than the marginal implications of tariffs. Long run marginal cost studies seem not to have affected the use of this style of tariff.

Long run marginal cost studies do appear to have had some effect on the relative weighting of charges for kWh and kW. The charge for kWh is more acceptable, even to quite sophisticated consumers, than the charge for kW; the latter is often regarded, and referred to, by consumers as a tax. Generally tariffs throughout the region understate the costs of capital expansion. Studies of marginal cost structure appear in some cases to have helped utilities persuade government to allow permitted increases in revenue to be raised disproportionately through increase in the capacity component of tariffs, where this existed. This can be a mixed blessing. The commonest form of tariff with a capacity component is the maximum demand tariff. Maximum demand for a consumer does not normally coincide with system maximum demand and can be a poor measure of cost. The economic justification for a shallow tubewell may require that the installation be charged only for kWh and not kW. A maximum demand or contracted demand type of tariff may put the tubewell out of business. This would hot be correct; the tubewell could without difficulty operate only during the off-peak period, in which case it has no capital implication for the utility.

The basic problem is that the allocational benefits of long run marginal cost pricing can only be properly obtained by a billing procedure which recognizes the time at which electricity is consumed in relation to system peak. This recognition may be based entirely on a time of day tariff structure or it may depend principally on a form of load management backed up by tariff incentives.

/The

The introduction of time of day pricing into tariffs would be a radical change. The cost of metering would initially limit the innovation to reasonably large loads. A principal obstacle is political. Incremental changes to existing tariff structures already attract a great deal of attention. Radical revision is bound to discriminate in favour of some and against others. Concern about the lobbying and attention which would attend revision is influential within some utilities.

For these or other reasons there is almost no time-of-use element in tariffs in the region. An exception is the Republic of Korea. Early indications are that a time-of-use pricing policy can be effective in shifting the demand of large industrial consumers to off-peak hours. The effect of time-of-use rates in the Republic of Korea is summarized in Table 3 (4).

Table 3. The Effect of Time of Use Rates in the Republic of Korea, 1976-1980

Load (percentage of average)	1976	1979	1980
Off-peak	80	82	84
Average	100	100	100
Peak	127	121	115

There has been a dramatic fall in the peak demand relative to the average. It appears that the peak has been cut by about 10 per cent; the implications for capital expenditure by the utility are important. It is noticeable that the off-peak load has not increased in proportion. It appears that the reduction in peak has been achieved not by redistribution of demand but by industry installing its own generating capacity as peaking plant. Normally the provision of peaking capacity is done most cheaply and efficiently by a central utility; it is possible that the changes observed in Korea do not represent an optimal use of resources. Tariffs which exagerate the marginal cost structure can be as inefficient as those which understate it.

Nevertheless there is a prima face case that industry does respond to time-of-use rates. Tariffs of this nature for large industry could well be appropriate in the region, particularly in those countries which at present have adequate capacity and reasonably reliable systems. Time-of-use tariffs are not appropriate in power systems where plant reliability is so low that load is regularily lost away from peak.

/Time-of-use

Time-of-use tariffs induce desirable behaviour in consumers. Similar behaviour can be imposed by physical intervention or through voluntary agreements with industry. The latter means constitute load management. Physical techniques are often accompanied by tariff incentives to compensate for loss of convenience. The shedding of load according to a pre-established priority by means of frequency controlled relays is not included as load management. In many developing member countries of the region this is the usual practice for matching supply and demand and is often necessary each day. Consumers adjust to this situation, but there is always some associated cost.

The techniques of load management of lowest initial cost are those which involve staggering of activity, either by staggering of holidays or by hours of work. Employers often agree to these arrangements without tariff incentives in order to improve reliability of supply during working hours. The practice is appropriate where the reliability of power supply is especially low. It is widely used in Southern Asia.

The forms of load management increasingly practised in industrialised countries are little used in the developing countries of the region. Many technologies for load management are currently available using local controllers or remote control systems. Where appropriate the control device is associated with an energy storage system or an alternative source of energy for use during the period when supplies from the grid are disconnected. Examples of local controllers are time switches, priority relays which prevent two or more high load appliances being used together and demand limiters which schedule loads or shed loads in a predetermined manner. Remote control systems allow control of load, generally but not necessarily by the utility. Signals sent by FM transmitters or imposed at low frequency on the utility wave form are used to switch loads according to predetermined schedules. Some systems permit two way communication which then permits other functions such as remote meter reading and data acquisition.

Load management of this type is normally applied to relatively small loads that must be managed together if there is to be any perceptible impact. Space heating loads in industrialised countries of the North are particularly appropriate because they contribute substantially to system peak, they are easily controllable and they can be substituted by stored heat. Most developing countries in the region do not have significant

/space

space or even water heating loads. In the middle income countries air-conditioning is significant at peak times. Cold storage systems using ice made during off peak hours can be obtained commercially. Control is usually provided by a timer. The effectiveness of such apparatus for load management depends on the load characteristic of the utility. Poor results have been reported from industrialised countries for residential applications because the demand is concentrated in the evening and at night. Commercial, institutional and industrial applications show better results, (5).

In developing countries the residential sector is unlikely to be receptive to load management. The commercial and institutional sectors could be interesting and some industries e.g. food processing. Management of irrigation loads has been given little attention in industrialised countries became it is of litle significance there. It is an important possibility in many of the developing countries of the region. A comprehensive investigation of the possibilities, costs and benefits of load management in the developing countries of the region appears timely. Consideration should be given to the tariff arrangements which will promote load management and fairly distribute its benefits.

/FUTURE

FUTURE ISSUES

Forecasting

The forecasting of future demand for electricity is a notoriously difficult and contentious business. Power plants can take upto ten years to complete from the initial decision to build. The choice of new generating capacity may require that the implications of various options be examined over twenty years or more. This is a much longer timescale than that feasible for practical macroeconomic forecasting or planning. The practical consequences of errors in forecasting become less important as the date recedes.

Forecasts of electricity demand are made in various ways. Commonly used techniques are:

- temporal extrapolation of past trends in power demand using time series analysis, regression analysis and/or judgement
- by a model of the relationship between electricity demand, national economic output and population. Assumptions about demographic and economic trends then can be used to predict electricity demand. The model parameters are usually calculated from regression analysis.
- by models which relate electricity to economic conditions in different sectors and regions and which then aggregate these forecasts
- by models which prepare an economically consistent and plausible future state of the economy in terms of physical activities and then assess the implications for electricity demand.

In developing countries the problem is compounded by the existence of suppressed demand in areas where there is no access to electricity. The forecasting of future demand must therefore make allowance for the geographical expansion of services. In Indonesia, where captive power plants provide a large proportion of supply, the growth of the utility is much influenced by the rate at which it can substitute the output from those plants.

In the past the temporal trend of demand for electricity has been stable and has been a reliable indicator for forecasting. Reliance on this method has penetrated deeply, although the conditions under which the technique is valid no longer hold. The technique relies on the belief that historic relationships will continue into the future; it is evidently unlikely to be of much help in identifying the consequences of structural change.

/Econometric

Econometric models also rely on historical relationships generally obtained by regression analysis. If changing circumstances are manifest through changes in the value of the parameters which are input to the model then models of this type can help assess the consequences of change. For example, if forecasts of electricity demand are made on the basis of the historic relationship with GDP and if future changing circumstances affect only the expectations of future GDP and not the relationship between GDP and electricity demand, then, in this situation the model will correctly predict electricity demand from correct forecasts of GDP. This is rarely how change occurs. In practice changing circumstances affect both the input parameters determining future economic circumstances and also the relationships between the input parameters and electricity use. This damages the logic of using econometric relationships derived from historic data for forecasting future demand. Models which incorporate the price of electricity relative to other factors of production and to other fuels will to some extent predict technological response to changing circumstances. The concepts underlying this type of formulation are simplistic and the data required to establish the various cross price elasticities is often not available in developing countries.

Structural change can be incorporated into end use models which specify the future condition of the economy in terms of physical activities (eg. tonnes of cement produced, passenger kms of railway transport etc) then calculate the implied requirements for electricity assuming appropriate efficiencies for the necessary components or appliances. In principle these models are powerful tools; they can capture the effects of relative price changes, new technologies, behavioural change and improvements in the efficiency of electricity use. In practice there is generally little to go on in predicting these varied effects; a great deal of judgement and guess work is needed. The specification of future scenarios is normative and tendentious. Useful though they can be, end use models may be no more than means of justifying preconceptions of what the future will be like.

The forecasting methodologies in use in the region vary considerably. Japan uses both econometric and end use models. The results of each are used to check, illuminate and understand the other. The majority of utilities in the developing member countries depend on econometric models of varying degrees

/Figure 10

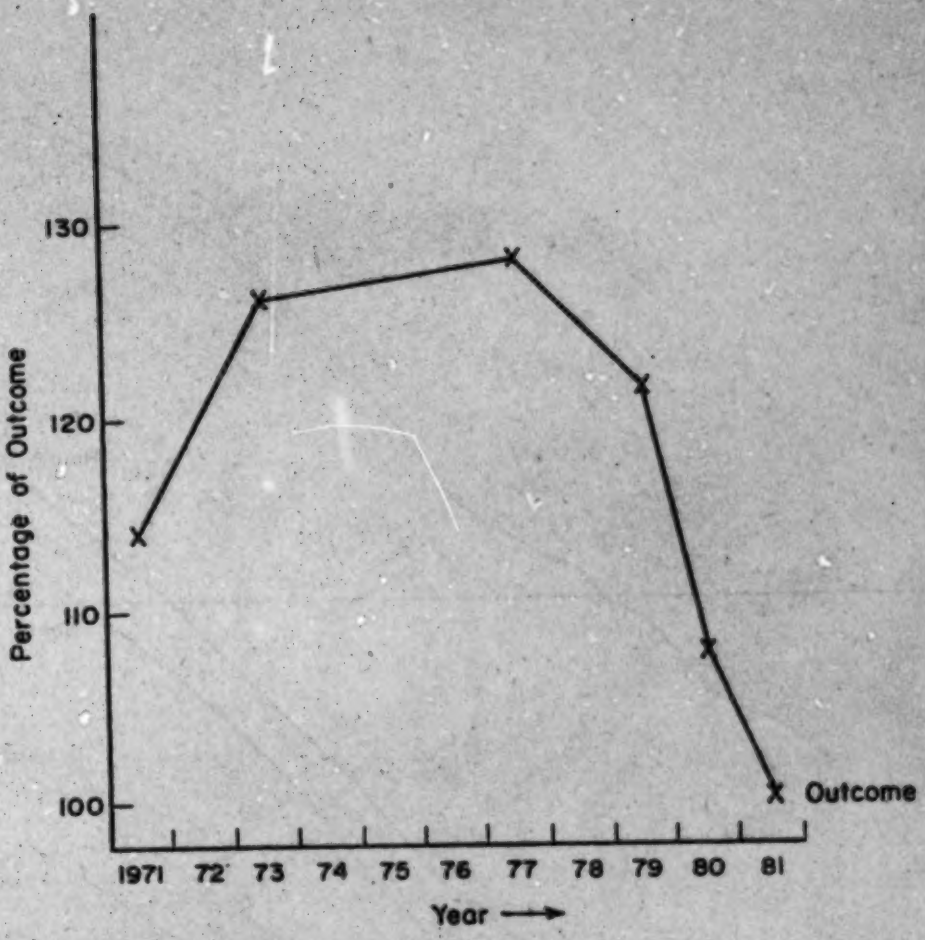

Figure 10 Forecasts of demand in 1981 made in various years as compared to the outcome

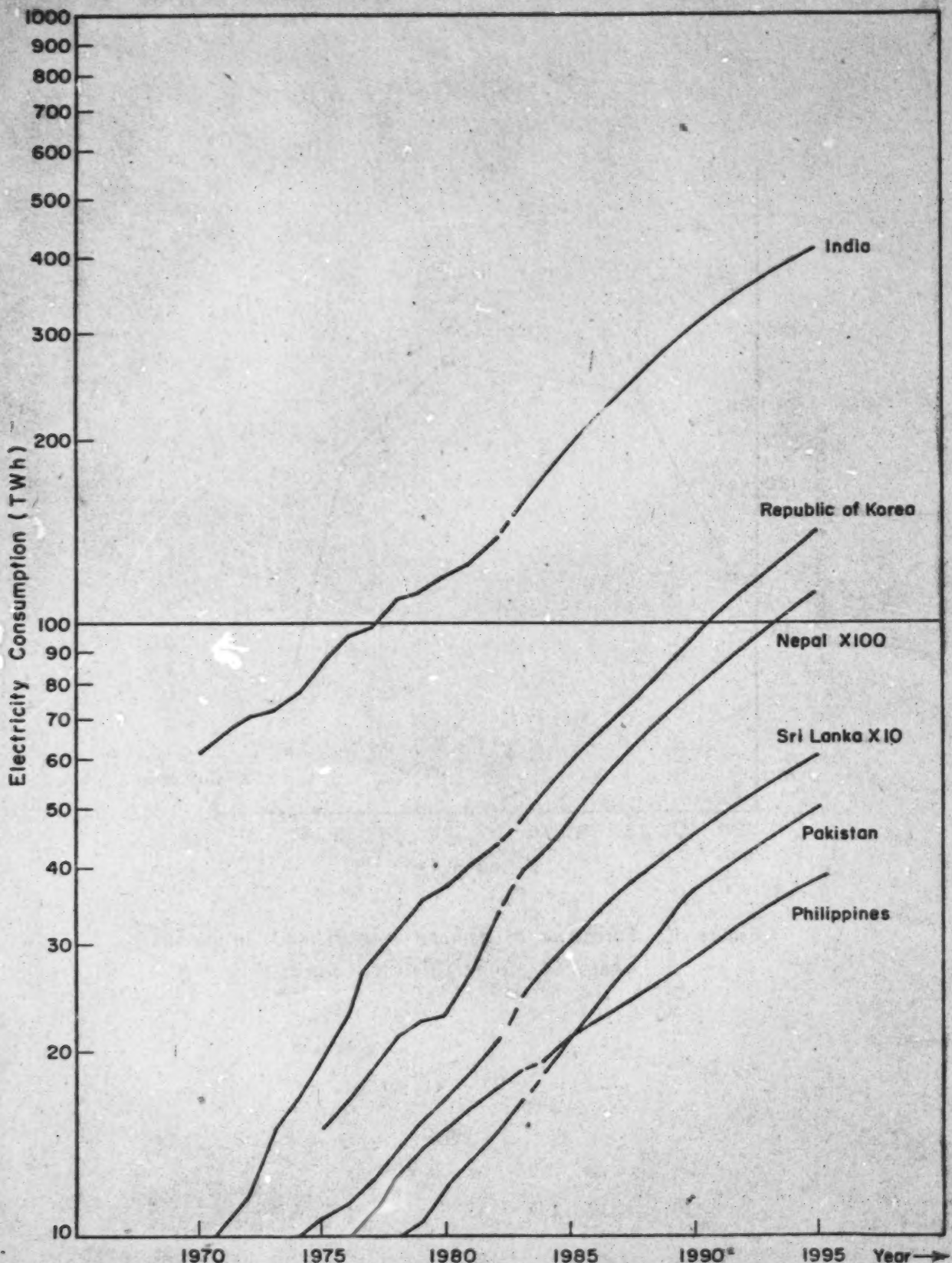

Figure 11. Historic electricity consumption and future forecasts for selected countries

of complexity. None of the models in use appears to include the price of electricity as a variable. Generally, though not always, the countries of South East Asia have developed econometric models which relate electricity demand to economic output disaggregated by sector and/or region. Step additions from planned large industrial installations are normally incorporated separately.

The results of these models are usually presented in terms of an annual growth rate for each year and an average for the period, so that they can be easily grasped and intuitively compared to past performance. Whether load forecasts are accepted and sanctioned by senior management depends on whether the annual growth rates seem plausible in the light of past experience. The simple extrapolation of past trends continues in this fashion to be an important moderator even when forecasting is apparently made using econometric models. That this is an informal rather then formal process should not detract from its significance.

In South Asia the methodologies used for forecasting tend to be simpler. Some utilities do not use econometric models on any regular basis. Forecasts are mostly made through judgements of what constitutes a probable annual growth profile. The relevance of forecasting to the utilities of this region is affected by the common shedding of load at peak and frequent delays in commissioning new plant. Demand outstrips both present capacity and the likely ability to extend capacity. In these cases the demand for electricity is limited by the availability of supply. Sophisticated methods of forecasting may not be appropriate.

As an example, in India the shortfalls in the achievement of planning targets in the first five plans were 15, 36, 33, 50 and 18 per cent. The sixth plan presently appears to be about 25 per cent behind the target. Given these circumstances and the large unsatisfied demand in the country, the significance of precise forecasts of demand is reduced.

As elsewhere in the world the past record of electricity forecasting in the region demonstrates that large discrepancies between forecast value and actual value can arise. The discrepancies are not necessarily found only in long term forecasting but may arise in the short term. Figure 10 shows a comparision of actual and forecast peak demand on a utility in the region.

/Substantial

Substantial discrepancies are evident even in the mid term forecasts. The general, but not exclusive, tendency is to overestimate demand. This is typical of the more developed among the developing countries of the region. It arises from a failure fully to allow for the adjustments of consumers.

Demand in the less developed among the developing countries is not so sensitive to general economic conditions, partly because these countries are among those which make the greatest effort not to pass cost increases directly on to consumers and partly because demand is much affected by the extent of access to electricity. In these countries it is not uncommon for actual demand to exceed forecasts in recent years. Bangladesh is an example. Actual growth in peak demand and electricity generation in the past ten years has been considerably higher than was projected internally and by external agencies.

Figure 11 shows forecasts of demand to 1995 for the total of the developing country members of ESCAP and some individual members. Many of the forecasts show a similar trend, characterized by reasonably rapid growth over the next few years, although not as rapid as the expansion of the seventies, followed by a lower, but steady, rate of increase in the remainder of the period.

Utility forecasts are constantly revised; those given in the figure are compiled from a variety of sources; some have been extrapolated to 1995. The forecasts shown should not therefore be treated as definitive, but simply as indicative of present thinking. Demand is expected to increase in the period from 1983 to 1995 by a factor somewhere between 2.5 and 3.5, depending on the country. These increases correspond to average annual growth rates, of between 7 and 11 per cent. These are lower expectations of economic growth than average historic growth rates presumably reflecting lower growth economic rate or a decoupling of growth and electricity demand, or both.

There may be some doubt whether the present forecasts adequately account for future adjustments by consumers to changes in the relative price of energy relative to capital, labour and materials. The techniques of forecasting in use in the developing member countries of the region do not appear to make much allowance for future structural change either econometrically

/through

through price elasticities or physically by revising relationships between economic growth and electricity demand. The slower than historic growth now anticipated arises largely from a slower than historic growth in expected output.

Figure 3 shows that there have been significant changes in the relationship between electricity use and output which have only fully developed over the past five years. The faltering and decline in specific electricity consumption which is evident in most countries will probably persist. Behavioural adjustments to relative price changes will persist; design changes to appliances will persist and will propagate further. It is not clear that current forecasts make adequate allowance for these factors.

It would be quite inappropraite, not to say impossible in this paper to make new and detailed forecasts for each member country. It is easy to show what current forecasts imply in terms of the future development of the relationship between electricity use and output.

Table 4 shows the implications for electricity demand of various average rates of growth in real economic output and various changes in the specific electricity consumption. The analysis considers real economic growth rates up to 7 per cent per annum and specific electricity consumptions which are 30 per cent above, equal to, and 30 per cent below the present value. The entries in the table are the number of times by which demand in 1995 is greater than demand in 1983. The entries in brackets are average growth rates in electricity demand over the period.

The historic growth rate of real GDP in the developing member countries of the region, excluding China, has been 6-8 per cent in good times. The average over the last twenty years is brought down by recessionary periods to about 5 per cent. Growth rates for the different member countries vary considerably from the average. India, which makes a large contribution to regional GDP has grown slowly at 3 to 4 per cent a year. Most of the other countries in the region have grown faster than the weighted average at rates in a band from 6 to 7 per cent.

/Table 4.

Table 4. Implications of Various Real Rates of Growth of Output to 1995 and Changes in Specific Electricity Consumption

Change in Specific Electricity Consumption	Rate of Growth in Economic Output (Percentage)					
	2	3	4	5	6	7
+30%	1.7 (4.1)	1.9 (5.1)	2.2 (6.1)	2.5 (7.1)	2.8 (8.1)	3.1 (9.1)
0	1.3 (2.0)	1.5 (3.0)	1.7 (4.0)	1.9 (5.0)	2.1 (6.0)	2.4 (7.0)
-30%	0.9 (-0.7)	1.0 (0.2)	1.2 (1.2)	1.3 (2.1)	1.5 (3.1)	1.7 (4.1)

Table 4 suggests that the forecasts of Figure 11 are only compatible with combinations of sustained high growth and a resumption in the tendency for specific electricity consumption to increase with time. For the majority of countries shown in Figure 3 the recent tendency has been for the specific electricity consumption to remain constant, or even to drop. A constant specific electricity consumption implies that electricity demand grows at the same rate as GDP. On this basis the forecasts in Figure 11 are substantially high. It is perhaps more likely that specific electricity consumption will fall in some if not all countries. A reduction of 30 per cent by 1995 is not at variance with present trends. A seven per cent average increase in real GDP would then only bring a 4 per cent increase in electricity demand. The difference between the implications of the two growth rates, accummulated over the period, is significant; about 70 per cent of present capacity.

One can conclude:

- future demand for electricity is critically dependent on the rate and extent of adjustment by consumers to high electricity prices
- this adjustment is clearly visible in historic data, but its future trajectory is hard to assess

/- current

- current forecasts of demand are only consistent with sustained high economic growth and increases in specific electricity consumption
- further study of the process of adjustment in the developing member countries of the region is desirable with a view to ascertaining its present character and likely future development. This work can then be incorporated in econometric or end use models which are appropriate to the region. These models should explicitly recognize the effect on demand of the degree of access to supplies throughout the country. It is more important to equip the developing member countries with the expertise to construct, implement and interpret their own models then to furnish them with generic models developed outside the region.

Future Generating Options

An earlier section has traced the historical process of substitution for oil and has indicated the likely future trend. This section deals in more detail the factors affecting the choice of plant to substitute for oil.

The details of the future mix of generating plant are more difficult to foresee than the gross transition from oil itself. It is clear that there are many sources which can be profitably developed at present oil prices; it is not so clear how they rank among themselves and what determines the rank. The alternative sources of generation are hydro, nuclear, coal, lignite, natural, gas, geothermal and the so called new and renewable sources of energy (NRSE).

Hydro

The hydro reserves of the region are indicated in Table 5. The table also shows the extent of development by 1982 and estimates of how much might be developed by 1990, for selected countries. The hydro power potential of the region is large, the sum of the estimates given is over 1,000,000 MW, or rather more than 400,000 MW excluding China. These figures do not mean a great deal, but they serve to indicate the enormous magnitude of the resource. There are constraints on development. The resource is unevenly distributed and with some important exceptions tends to be distant from load centres. By and large, hydro potential is concentrated in mountainous terrain which is not congenial to economic development.

/Table 5.

Table 5. Water Power Potential and Development in Selected Countries

Country or Area	Capacity (MW)			Ratio of Installed to Potential (percentage)
	Estimated Potential	Present Installed (1983)	Estimated Future (1990)	
Afghanistan	5000 (+18000)*	262		5
Bangladesh	1138	130	130	11
Burma	2000	169	590	8
China	680000	23000		3
Fiji	300	80		27
India	75400	12174	26000	16
Indonesia	77863	1355	4350	2
Japan	47384	24911	45000	53
Lao PDR	13213	113		1
Malaysia				
Peninsular	2190	718	1133	33
Sarawak	12092	0	0	0
Nepal	83000	113	300	<1
Pakistan	25000	2547	4790	10
Papua New Guinea	15075	116	150	1
Philippines	8000	1680	2200	21
Republic of Korea	3000	820	1770	27
Sri Lanka	1540	400	850	26
Thailand	8009 (+14000)*	1520	2700	19
Viet Nam	2000	163		8

* Potential of international rivers common to neighbouring countries

Note: Estimates for different countries are made on different bases and with varying degrees of care. Only general comparison is possible.

Several countries will be approaching economic and practical limits of development by 1990. These countries include the Republic of Korea, Japan, Peninsular Malaysia and Sri Lanka. Other countries still have considerable reserves to be developed progressively after 1990. The principal countries in this group are India and Pakistan. Then there are very large resources remaining in countries or regions which do not have a commensurate market and on international rivers which can only be developed practically with the collaboration of several countries. The first group includes resources in Afghanistan, Laos, Indonesia, Burma, Sarawak, Malaysia and Papua New Guinea. The second group includes the Mekong River, The Salween River and the rivers of Bangladesh Nepal and North East India.

If hydro electricity is to contribute strongly to incremental demand for electricity past 1990 or 2000, except for a few favoured countries, then it will have to be through the development of large remote resources to the benefit, and with the collaboration of more than one country.

The political and managerial difficulties are considerable. Successful collaboration does exist, albeit on a small scale. The Nam Ngun project on a tributory of the Mekong in Laos supplies power which is exported mainly to the Thai system. The 30 MW first phase of the project was completed in 1971 and the second phase of 80 MW in 1978. The operation has benefitted both countries.

Serious interest is being shown in the Kanali project to build a 3600 MW generating plant in Western Nepal, the output of which would go mainly to India. There is considerable complementarity in the interests of the two countries. Nepal has a large trade imbalance with India; in the future the most practical means of maintaining a balance is to export electricity. India benefits because the marginal costs of supplying electricity to her frontier areas are high and because the hydro will facilitate operation of her large new coal plants. India would also enjoy the benefits of flood control and irrigation. Studies have been made and invitations have been issued for bids for detailed investigations.

There are likely to be many difficulties in managing these large projects and in sustaining the political will to develop them. A principal problem will be in measuring the benefits, deciding how they will be allocated and in agreeing tariffs which bring about the agreed allocation.

/For

For example a dam in one country may improve the water management in a neighbouring country; arrangements for valuing that benefit and agreeing appropriate payments to the upstream country may be difficult. Similar problems can be foreseen in the development of rivers flowing along international boundaries. The exhaustion of easier opportunities in other parts of the region will enhance the value of collaborative projects. Feasibility studies of possible successful political negotiation be well characterised.

Nuclear

Experience of nuclear power in the region is varied. In the North East there is a significant resort to nuclear energy, based on imported technology. In India there is a substantial programme with a large local element. There are plants in the Philippines and Pakistan and there has been sporadic interest elsewhere.

The advantage of nuclear power is that it can have, in principle, low unit cost. In developed countries nuclear power is considered to be secure from supply interruptions and this is postulated as a second advantage. Nuclear energy is not perceived by developing countries in quite the same way. The recent problems experienced by some countries in obtaining fuel for their reactors have emphasized that without control over the fuel cycle the supply of nuclear fuel is vulnerable.

There are also technical obstacles to the development of nuclear power in developing countries. Because of intrinsic economics of scale combined with the manufacturing structure of the nuclear vendors, the low costs of nuclear electricity are only achieved in plants that are too large to fit conveniently into most of the utilities of the region. The smallest commercially viable reactor size is about 600 MW(e), some would say 900 MW(e). In a small utility such a plant attracts penalties. Reserve margins must be higher to maintain similar levels of reliability; plant has to be despatched sub-optimally to keep adequate spinning reserve.

The high capital cost of nuclear plant and its technical complexity makes the option vulnerable to delays and cost overruns. Managerial difficulties and uncertainties of large construction projects can be acute. The experience of the Philippines is a case in point. Technically the nuclear project in this country has proceeded well, but substantial increase in the cost and long delays have detracted from the economics of the venture.

/Experience

Experience of commercial nuclear power has shown that plant factors can be low, especially in the early years. If this is the case then the economic viability is affected. Experience also shows that the availability of nuclear plant is uncertain. Some plants have achieved much higher availabilities than others. This consideration adds to the economic risk of a nuclear venture.

Whether nuclear power is appropriate for a particular utility can be discussed in terms of two threshholds. One is a threshhold on system size. If 600 MW(e) is the minimum economic size then the plant is unlikely to be practical in a system smaller than about 6000 MW(e), depending on the nature of the other plants on the system. The threshhold may be reduced if the limit on the size of commercially viable plant can be reduced. Much theoretical interest is being shown in this possibility, but there is little commercial activity to date.

The second threshhold is a managerial threshhold. The management and regulation of nuclear power plant requires a broad basis of skilled personnel in the utilities, government, nuclear agencies and regulating agencies. This is a significant appropriation of scarce resources. It may be that the effort can only be justified if there is a reasonable probability of a series of nuclear plants and not a single project.

Management of nuclear power projects can also be complicated by the many agencies that are generally involved in making decisions. The utility must often co-ordinate with a nuclear agency, a regulatory agency and several technical Ministries e.g. Finance, Energy, Industry and Trade. Military and foreign policy implications will increase the number of participating institutions. Split responsibilities and conflicting interests can slow down and often halt progress.

The countries of North East Asia have relatively large systems, few natural resources and enjoy the advantage of nuclear programmes begun when the costs were lower than they are now. They will continue to build nuclear plants and will generate considerable volumes of electricity from this source by the end of the century, perhaps 40 to 50 per cent in the Republic of Korea and the Taiwan province of China.

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The countries of South East Asia are unlikely to resort significantly to nuclear power before the end of the century. Not only does the earlier reasoning lead to this conclusion, but the expansion plans of the utilities confirm it. Even then there may be something to be said for collaborative developments of a bilateral character. Considerations of system operation and reliability and economic risk might encourage such an approach. The ASEAN countries are beginning to show a capacity for collaboration in the power sector; it might be usefully developed into joint projects.

The majority of countries in South Asia are also unlikely to make a significant resort to nuclear power in this century. India is a case apart; she has successfully adapted pressurized heavy water technology to her needs. Manufacture has standardised on a 235 MW(e) unit. The local content has increased from 55 per cent in the first PHWR commissioned at Rajastan in 1972, to 90 per cent in the two units at Kakrapar scheduled for commissioning in 1991/92. India is considering exporting reactors to other developing countries. The plant factors achieved on the nuclear plant in India are low and little is known about costs. The acceptability to foreign buyers is hard to gauge. The possibility of exports should not be ignored.

Pakistan has one nuclear plant near Karachi which has experienced some problems in operation. Tenders have been sought for a second plant of 900 MW(e), but apparently no bids have been received. Pakistan has considerable hydro reserves still to develop and some local coal in the mid term. The economic case for base load nuclear plants will strengthen towards the end of century.

Coal

Imported coal could supply a large part of the future electrical generation in the region. The international trade in steam coal has grown rapidly. In 1977, 60 million tonnes were traded internationally; by 1980 trade had increased to 110 million tonnes. The World Coal Study in 1977 suggested that by the year 2000 up to 680 million tonnes of steam coal would be traded, (6). It is now clear that this will not happen.

As a consequence of excessively high forecasts in the mid and late seventies investments were made in coal production which have not been fully used. Coal prices are accordingly depressed and are no guide to long run prices. In the long run, imported coal will be available in the Asian region at prices corresponding to the costs of the marginal suppliers. These will be southern Africa, Australia and west USA. Local producers such as China,

/India

India and Indonesia and other distant producers will not affect the price. Estimates of future mining costs in the marginal producers vary, but it is likely that coal can be delivered at Asian ports towards the end of the century at between 60 and 70 US dollars per tonne at current prices. Imported coal, in a somewhat similar manner to nuclear power, benefits from a large committment. There are economies of scale in generating plant, shipping and handling.

Large markets for coal are appearing in North East Asia and the trend will continue. The scale of the power systems and the shortage of indigenous resources justifies and facilitates this development. By 1995/2000 the generation from coal may be 15 per cent in Japan, 20 per cent in the Republic of Korea and 35 per cent in the Taiwan province of China.

The situation in South East Asia is not clear. The Philippines and Indonesia have firm plans for coal generation; it is uncertain how much can be supplied from local sources. In the other countries of the region much will depend on the future availability of local fuels and on depletion policies for natural gas.

In South Asia, Sri Lanka has concluded that the cheapest way of meeting future incremental demand for power will be by importing coal at the deepwater port at Trincomalee on the North East side of the island. In Bangladesh the expansion of the power system is planned almost exclusively on the use of natural gas. Known resources will be exhausted towards the turn of the century. The present acceptance of the rapid depletion of this local resource will probably not endure. In the absence of large new discoveries, imported coal is likely to be the preferred alternative. In Pakistan the depletion policy towards natural gas has taken a conservative swing. Local coal is usable, but supplies are small. Thermal generation of some sort will be needed by the end of the century; nuclear is preferred but imported coal may prove more practical.

The logistics of future coal trade were the subject of a recent ESCAP Expert Group Meeting, (7). The study suggested that the present status of the region as a net coal importer will change at some point around 1990 as Australian production of steam coal displaces present imports from outside the region. The study estimates that trade among the countries of the region will reach 100 million tonnes at least by 2000.

/Natural

Natural Gas

Natural gas is present in many countries of the region. In the past natural gas was not valued as highly as oil and not sought so eagerly. Economic circumstances have to some extent altered that situation; the presence of national oil companies in exploration may also be significant. There are accordingly some grounds to believe that substantial new finds may be forthcoming.

At the present time, in the context of developing countries, there is relatively little concern about whether gas is best used in power generation. A recent report by the World Bank alleges that the net back from use of natural gas is highest for power generation, among the bulk uses normally considered in developing countries. There is certainly no doubt but that gas valued at the cost of production will produce cheap electricity. The mineral rent from gas deposits is being used to subsidise electricity production in several member countries.

The opportunity cost of gas in the region is generally higher than the production cost. The opportunity cost is the cost of the marginal substitute fuel at a future time discounted to the present. Some consideration should be given to this in gas pricing policy. The scope for ambiguity in such calculations is great; it is not clear what effect the adjustment would have on the viability of natural gas for power generation. A change of attitude and the formulation of conservative gas policies is quite likely, especially if exploration is disappointing.

Local Generation

The main thrust of policy in power systems is towards large plant which maximise the benefits to be obtained from economies of scale, rents from favorable locations and access to low cost fuels. There is neglect of other efficient means of generation which benefit from being integrated into a joint process. Usually the joint process will involve the combined generation of heat and power or the use of a combustible waste as fuel.

The relevant question for policy makers are:

- is there a resource to be tapped?
- is it economically accessible?
- what prevents its development?
- what can be done to facilitate it?

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The combined generation of heat and power is practised almost everywhere in the region in the industries with large demands for process heat. Most of the experience of the region is in cogeneration of electricity and process heat, although there is a large district heating scheme in Beijing. There is no doubt that considerably more power could be generated in such plant, both by reversing the historic trend away from cogeneration and by altering the design of plant to use more cost effective prime movers or higher steam conditions.

The question as to whether it is economic has to be answered in two contexts. Firstly, in the case when the cogeneration system is isolated from the grid. Secondly when it is interconnected. The scope for increasing the size and number of isolated cogeneration systems may be limited. Isolated systems require large percentage reserves to give acceptable reliability. From an engineering perspective it is almost always better to interconnect cogeneration systems with the grid; the connection allows freedom of design and flexibility of operation. The engineering benefits have to be off set against managerial disadvantages. There are conflicting objectives between industry and power utilities; the location of the industry may not be ideal; there is always contention over the division of benefits. One should note that when prices are less than long run marginal costs, as is universally the case in the region, then the utility should logically be prepared to pay more for electricity from a local producer than its selling price. An appraisal of cogeneration schemes valuing the outputs at long run marginal cost would increase their attractiveness.

It is not at all clear what inhibits interconnected cogeneration schemes in the region. Many utilities in the region regularly buy electricity from industries to meet peak demand. From the proceeding of the recent ESCAP workshop on cogeneration of electricity and process heat it does not appear that low tariffs for purchase of electricity by utilities are a critical constraint, as is often alleged in developed countries, (8). The proceedings seem to suggest that the main impediment is a general lack of awareness and interest in the technology as a part of power system policy. If this is the case then the measures proposed in those proceedings, for dissemination of information and creation of awareness, are the appropriate procedures. Work on a regional level should be complemented by country studies to determine in detail what the potential of cogeneration might be, what prevents it and how the situation could be corrected.

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The more efficient use of agricultural residues in the food processing industries presents much the same policy considerations. Sugar refining is a good example. A recent World Bank study showed how bagasse could be used more efficiently by simple technological improvements to the average plant. The modifications include various heat exchange processes, higher steam pressures and to compress bagasse to allow annual storage, (9).

New and Renewable Sources of Energy

There is great interest, both at technical and political levels, in the possibilities of using renewable energy sources to generate electricity. Many schemes for using new and renewable energy resources have been demonstrated to be technically feasible. It is possible, given enough time and money, to make lot of things work. Eventually renewable energy devices must be shown to be commercially and economically viable and acceptable to users. This requirement does not exclude the possibility of subsidy but the framework of subsidies needs to be permanent and the government should be prepared to accept the implications. The essential behavioural characteristic to look for is that the technology should replicate spontaneously; it should be adopted volontarily by users because it is an economic and reliable means of meeting their needs, albeit possibly in the framework of long term subsidies.

There are two renewable resources which might be said to have reached this stage in the region. They are mini hydro and charcoal fuelled gasifiers. Mini hydro has been demonstrated in many countries in the region. The cost of generation in a remote area can be many times less than generation from isolated diesel engines; the details of comparison depend on circumstances. The technology is appropriate to remote areas with hills and water. This includes Afghanistan, China, Indonesia, Nepal, Northern Pakistan, and the Philippines. There are less general opportunities in Malaysia, Thailand and Fiji and Papua New Guinea.

Charcoal gasifiers have received considerable attention in the Philippines. It may be that the commercial programme was launched prematurely before the design had been sufficiently refined. Nevertheless there are signs of genuine spontaneous interest among consumers. Some users have shown enough enthusiasm to develop improved designs of gasifiers. This is encouraging

/Neither

Neither micro hydro nor charcoal gasifiers are competitive with electricity from a grid reasonably close by, but large areas of the region do not enjoy this facility. These technologies may be particularly appropriate to the islands of the region where the necessary resources exist. The islands depend heavily at present on imported diesel oil for power generation. The cost of transport is high and improves the economic feasibility of renewable resources in comparison with alternatives. It should be stressed that although these two renewable technologies show promising signs their application is limited by the availability of the renewable resource. The acceptability of micro hydro is now clear; it is not so certain that charcoal gasifiers will be able to confirm the acceptability which they tentatively appear to enjoy.

The technical viability of solar photovoltaics in the region has been proven by several projects. The technology is economically viable for small, specialised applications in remote areas. Commercial applications of a general character have yet to be proven and probably depend on substantial reductions in the cost of fabricating the photovoltaic cells.

Diesel

Small scale generation by diesel power plants is the main and sometimes the only mode of electricity production in the small islands of the region. It is the only source of power in the Cook Islands, Fiji, Kiribati, Nine, the Solomon Islands and Tonga. It is almost the only source in Samoa. Diesel Generation is also important in remote areas of the larger countries; Indonesia, The Islamic Republic of Iran, Malaysia, the Philippines, the Republic of Korea and Thailand have large quantities of diesel installed.

In some of these countries it is likely that diesel generation will give way rapidly to grid extensions. In others and especially in the island countries it will persist. There will be a tendency for the emphasis to shift from small high speed engines operating on gas oil to larger, lower speed engines operating on base load with heavier oils.

Regional Collaboration

The prospects for regional collaboration fall into two groups. There can be collaboration on specific projects between two or possibly more partners and collaboration in management problems which would normally be best done multilaterally. The most outstanding example of collaboration on projects is the exploitation of international rivers or of large hydro resources remote from

the load centres of the country within whose political boundaries they fall, but capable of economic development for use in neighbouring countries. The example of Nam Ngum in Laos has been cited earlier. This is a small project in comparison with those which could be undertaken.

Nepal has on enormous potential for hydroelectric power. This potential cannot be seriously or optimally developed without the collaboration of neighbouring countries. Operation of even run-of-the-river plants would benefit from power exchanges with neighbour; the large seasonal fluctuations being compensated by thermal generation in neighbouring countries. Storage plants would confer extra benefits by controlling floods and augmenting dry season flows.

The hydro potential of the Mekong River is also large. Estimates vary, but it certainly exceeds the combined maximum demands of the riparian countries for a long time to come. Development of this resource requires the cooperation of Thailand, Laos, Kampuchea and Vietnam. A permanent committee of ESCAP is charged with the promotion of cooperative development. Political difficulties have so far prevented progress. The salween river in Burma has large potential; development requires collaboration with Thailand. The hydro potential of Lake Toba in Sumatra is considerable; any practical scheme would require that large volumes of power be exported to Malaysia and Singapore.

The obstacles to implementation of specific projects vary from project to project. Technical difficulties are severe in some, not in others. The main obstacles in general to collaboration of this nature are political. These political difficulties will persist. Continued scrutiny and reconsideration of feasible developments is nevertheless desirable in order that the public perception of the possible benefits should not fade. International agencies have an important role in this context. Some progress is being made. A project to develop a barrage on the Kanali river in Nepal and to export power to India is at an advanced stage of study with World Bank financing.

It is also probably the case that the economically optimal design of power systems would involve considerably stronger interconnection between countries. National utilities always tend to resist this idea, but it hardly seems likely that national frontiers should invariably coincide with desirable boundaries for grid systems. A heavier interconnection of Thailand, Malaysia and Singapore could be beneficial. Power supply to the western zone of Bangladesh would be facilitated by electrical interconnection with India. An electricity transmission system for Nepal, the adjacent areas of India and extended further to Bangladesh might be useful.

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The question of interconnection is strongly linked to the common development of hydro resources. In both cases the proper basis for progress is though initial feasibility studies at a technical level followed by discussions to identify and solve political problems later. Without proper feasibility studies the necessary political will can neither be sustained nor directed.

The second category of collaboration comprises managerial topics. It is clearly impossible for any single utility in the developing member countries of ESCAP to support the same managerial systems in width and depth as the utilities of the developed countries. Japan for example generates about as much electricity as the whole of developing ESCAP, including China. The possibilities in terms of computer applications, training, economic analysis and planning are correspondingly greater.

The disadvantages of small size can be reduced by pooling of resources and experience. The ASEAN countries have made considerable progress in this area. The utilities of ASEAN have a Computer Applications Group which has acquired, with finance and assistance from the Asian Development Bank, a common programme for the planning of transmission systems.

The ASEAN power utilities have created a permanent forum for cooperation in the meetings of the Heads of ASEAN Power Utilities. The projects of this group vary in character and emphasis; they cover mini and micro hydro, computer applications, interconnection, research development and engineering, training, geothermal power development, nuclear power, rural and urban electrification, standardisation and an information centre on electric power. No doubt some of these initiatives will flourish and some will wither; the potential benefits of the general arrangement are great. Taking the project on training as an example, it is envisaged to establish a Management Development Programme comprising modules which are separately the responsibility of different utilities. The programme would be given within the ASEAN region at different places. Consideration is being given to specialisation of training activities within member countries and some progress appears to have been made. There is little collaboration in the region outside of the ASEAN experiment. A cooperation programme exists between Bangladesh and Thailand, but it is on a small scale. A greater degree of exchange of information and collaboration is desirable within the region.

/RECOMMENDATIONS

RECOMMENDATIONS

1. The relationship between electricity demand and other economic, demographic and social factors in the region is still poorly characterised. Progress is likely to be made through the creation and development of local expertise rather than the imposition of generic models developed outside the region. A comparative study of these relationships in the countries of the region should be initiated.

2. The general lines of the transition from oil in the power sector are reasonably clear up to 1995/2000. It seems that the region has the means to support alternatives on an adequate scale. It is not so clear what are the best lines of development past this date. Whatever choices are made will require long lead times and will probably benefit from a degree of collaboration. A regional study of the options for power generation post 2000 and the implications for regional collaboration should be undertaken.

3. Among the prospects for power generation in the distant future are large collaborative hydro schemes. It would be useful to determine what projects are technically feasible, what real possibility there is that they can be organised and what the implications would be technically and on policy for power generation in the countries affected.

4. Although there is locally quite advanced collaboration on management matters there is poor exchange of information and experience throughout the region. It is desirable to initiate such a development at a regional level.

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